Eden Isotope Production Complex
Construction Permit Application

Enclosure 3:
Public Version
Preliminary Safety Analysis Report &
Environmental Report

eden | Precision Science. Human Impact.

EDEN ISOTOPE PRODUCTION COMPLEX
PRELIMINARY SAFETY ANALYSIS REPORT

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Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 1
The Facility

Precision Science.
Human Impact.

CHAPTER 1
THE FACILITY

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ac.	acre(s)
Al	aluminum
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
CFR	Code of Federal Regulations
DC	design criteria
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
ha	hectare(s)
HCF	Hot Cell Facility
HEPA	high-efficiency particulate air (filter)
HEU	highly enriched uranium
HFIR	High Flux Isotope Reactor
HVAC	heating, ventilation, and air-conditioning
I-131	iodine-131
I&C	instrumentation and control
ISG	Interim Staff Guidance
km	kilometer(s)
LEU	low-enriched uranium
mi.	mile(s)
Mo-99	molybdenum-99
MWt	megawatts-thermal

Acronym/Abbreviation	Definition
NM	New Mexico
NM-176	New Mexico Highway 176
NRC	U.S. Nuclear Regulatory Commission
NWMI	Northwest Medical Isotopes, LLC
ORNL	Oak Ridge National Laboratory
PSAR	Preliminary Safety Analysis Report
R&D	research and development
RF	Reactor Facility
SCB	steel confinement box
SHINE	SHINE Technologies, LLC
SSC	structure(s), system(s), and component(s)
TRIGA	Training, Research, Isotopes Production, General Atomics
TQP	Target Qualification Plan
TX	Texas
U-235	uranium-235
UPSS	uninterruptible power supply system
URENCO	Urenco USA
UREX	uranium extraction
U.S.	United States
WCS	Waste Control Specialists
Xe-133	xenon-133
Y-12	Y-12 National Security Complex

1 The Facility

1.1 INTRODUCTION

Eden Radioisotopes, LLC (Eden) is a privately-owned, development-stage New Mexico company created for the purpose of designing, constructing, and operating a radioisotope production facility for the production and marketing of radionuclides to the nuclear medicine community. Eden uses proven, proprietary nuclear reactor technology specifically developed to produce diagnostic and therapeutic medical radioisotopes. Eden, the applicant, is requesting approval for a construction permit to construct a medical isotope production facility (i.e., Eden Isotope Production Complex [EIPC]). The EIPC consists of the Eden Medical Isotope Facility (EMIF) and other support buildings. Figure 1.1-1 provides a visual rendering of the buildings on the project site. The EMIF contains both a utilization facility (Reactor Facility [RF]) and radioisotope production facility (Hot Cell Facility [HCF]). The EIPC is to be located in Lea County, New Mexico (NM). Figure 1.1-2 shows the proposed site location within New Mexico.

The EIPC is considered a production facility in that the quantities of special nuclear material meet the definition in Title 10 of the Code of Federal Regulations (10 CFR) 50.2. This Preliminary Safety Analysis Report (PSAR) is submitted in accordance with the provisions of 10 CFR Part 50, Domestic Licensing of Production and Utilization Facilities, in support of the application by Eden to construct the EIPC.

This PSAR follows the content and organization of NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content, as augmented by the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for Licensing Non-Power Reactors: Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors, October 17, 2012.

The operation of the EMIF is primarily focused on the irradiation of low-enriched uranium (LEU) metal foil targets within the RF, followed by the processing of the irradiated targets in the HCF to produce the isotope molybdenum-99 (Mo-99), iodine-131 (I-131), and xenon-133 (Xe-133) through the fission process and other isotopes, such as lutetium-177 through neutron activation. The fabrication and assembly of the LEU metal foil targets occur in the HCF, and the targets are subsequently transferred to the RF for irradiation as described above.

This chapter provides an overview description of the topics that are covered in detail in later chapters.

1.2 SUMMARY AND CONCLUSIONS ON PRINCIPAL SAFETY CONSIDERATIONS

This section identifies safety criteria, principal safety considerations, and the resulting conclusions for the EMIF structures, systems, and components (SSCs).

1.2.1 CONSEQUENCES FROM THE OPERATION AND USE OF THE FACILITY

At the EIPC, the primary consequences resulting from the operation of the EMIF are radiological. The EMIF produces Mo-99 from irradiation of LEU targets in the RF followed by processing in the HCF. The LEU is in the form of individual annular targets (fuel). A target consists of a uranium metal foil clad with aluminum (Al) tubing in an annular configuration that allows for cooling on both the inner and outer cladding surfaces. The uranium foil is LEU with a nominal uranium-235 (U-235) enrichment of 19.75 weight percent. In the RF, the targets are designed for operation in a steady-state mode at an average power level of 30 kilowatts thermal each. This is described in more detail in Chapter 4a. The irradiated target is then processed in the HCF to extract and purify the Mo-99. This is described in Chapter 4b.

The EMIF is controlled as a restricted area. Doses to workers and the public during normal operation are within the limits of 10 CFR 20.1201 and 20.1301, respectively. In addition, there are potential exposures to the public from postulated accidents. Potential dose to workers and the public during normal operation is described in Chapter 11. Potential dose to workers and the public during off-normal events is described in Chapter 13.

1.2.2 SAFETY CONSIDERATIONS

Safety considerations influenced the site selection. The site selected is in a sparsely populated, undeveloped, non-food producing rural area. The traditional land uses in the area are for the oil and gas industry with some light cattle grazing to the south. The project site is on an approximate 240-acre (ac.) (97 hectares [ha]) square parcel.

The site has immediate access to a major highway, NM Highway 176 (NM-176), which permits timely access to the Lea County Regional Airport in Hobbs, NM, and, for backup, the Midland International Air and Space Port airport in Midland, Texas (TX). The highway provides efficient access to infrastructure and services provided by the City of Eunice.

The site is near another nuclear facility, the Urenco USA (URENCO) enrichment facility, approximately 1.3 miles (mi.) (2.1 kilometers [km]) to the northeast, which may allow for mutual benefit sharing of resources for environmental and radiation monitoring and control as well as emergency and security planning and response.

A major consideration in selecting the site was proximity to the low-level waste disposal site operated by Waste Control Specialists (WCS) approximately 2.6 mi. (4.2 km) to the east-northeast on NM-176 at the New Mexico–Texas state line. The proximity to WCS limits exposure of the sparse public population in the area to radioactive materials during waste transit. Further discussion of factors influencing the site selection is contained in Chapter 2.

The reactor is a steady-state, non-power reactor. The reactor core is comprised of individual annular LEU targets and is an open-pool design that uses light water as the moderator and coolant. Optimized production requires the all-target reactor to be run in the steady-state mode at a thermal power of 1.8 megawatts (MWt) continuously, with planned periodic short-term (i.e.,

order of hours) reactor shutdowns to remove and replace targets for processing. The reactor is described in more detail in Chapter 4a.

The EIPC buildings include areas for the use and storage of licensed materials, ancillary spaces, site access control, and administrative offices. The EMIF, consisting of the RF and HCF, is the nuclear facility and contains the only safety-related SSCs on the site. The safety-related structural portions of the RF consist of the reactor pool structure and base mat, and the transfer canal structure and base mat. The safety-related structural portions of the HCF consist of the HCF uninterruptible electrical power supply system room, the HCF mechanical equipment room housing the HCF Zone 1a fan/filter trains, and the HCF target processing canyon/waste storage canyon reinforced concrete walls, slabs, and base mat. Other buildings and areas are nonsafety-related. This is described in more detail in Section 3.5.

1.2.3 INHERENT AND PASSIVE SAFETY FEATURES

The all-target reactor contains many inherent and passive safety features that enhance its operation. These features are as follows:

- Low core fuel mass.
- Low core fission product and actinide inventory.
- Low steady-state power level.
- Low target fuel temperature.
- Passive natural circulation cooling.
- No active shutdown cooling requirements.
- Negative fuel temperature, moderator temperature, and moderator density reactivity feedback.
- No requirements for emergency backup power.
- Simple operation and shutdown features.
- The 60-target core configuration cannot be formed into a critical geometry in water without the beryllium reflector.
- The annular target design.

The core is designed to optimize Mo-99 production while minimizing the amount of LEU in the reactor. Because the complete core is replaced on a regular cycle (i.e., targets are processed every 7, 14, or 21 days), the buildup of long-lived fission products and actinides in the targets is minimized.

The reactor is a non-power reactor that operates in the steady-state mode at a power level of 1.8 MWt. The targets have a large heat transfer area with the annular cladding cooled on both the inner and outer surfaces. Due to the volume of water in the reactor pool and design features discussed in Chapter 4a, core cooling uses natural circulation and forced coolant flow is not required. The large reactor pool provides adequate heat capacity to allow for passive cooling capability with the reactor shutdown. The reactor pool also provides biological shielding and radionuclide retention under accident conditions.

The core maintains negative prompt temperature reactivity feedback for normal operation and during accident conditions. Because the core is passively cooled during shutdown, no safety-related emergency backup power requirement is needed for cooling the reactor. A loss of electrical power de-energizes the magnet power supply in the reactor control room, allowing the safety and control rods to decouple and fall by gravity into the core, placing the reactor into a safe shutdown condition. These features allow for simple, well-defined, and characterized operation of the reactor core with minimal risk to the worker, public, and environment.

The target design provides an inherent and passive safety feature because all the fission products are retained in the metal LEU foil and nickel recoil barrier, and there are no gaps between the fuel and the cladding.

The RF features presented above are described in more detail in Chapter 4a.

Irradiated targets are removed from the reactor and transferred underwater between the RF and HCF via a transfer canal which ensures that radiation exposure to the worker is minimized for this activity. These features are described in more detail in Chapter 9a.

The inherent and safety features of the HCF during irradiated target processing are the thick shield walls, the steel confinement boxes (SCB), and the filtered exhaust ventilation system. These features are described in more detail in Chapter 4b.

1.2.4 DESIGN FEATURES AND DESIGN BASES

The design criteria (DC) for the EMIF SSCs are described in Section 3.1. The system-related sections throughout this document describe how the design bases, including the DCs, are addressed.

The design of the facility and systems is based on defense-in-depth practices by providing successive levels of protection such that health and safety are not wholly dependent upon any single element of the design, construction, maintenance, or operations of the facility. Specific design features to support safe operation of the facility include:

- Large open reactor pool and transfer canal structure designed to establish the boundary and support water shielding of the irradiated targets, ensure radionuclide retention during design-basis events, and to maintain safe conditions during and after design-basis events and the design-basis earthquake as described in Chapter 3.
- Confinement within the HCF during the dissolution process via SCBs 2 through 7 and the HCF Zone 1a ventilation during design-basis events as described in Chapter 6b.
- Safety-related electrical power via an uninterruptible power supply to ensure continued operation of select loads during design-basis events or loss of off-site power as described in Chapter 6b and 8.

The SSCs at the EMIF are assigned a nuclear safety classification, as follows:

- Safety-related SSCs: Those SSCs that are relied upon to remain functional during normal conditions and during and following design-basis events.
- Nonsafety-related SSCs: Those SSCs that are not in the above nuclear safety classification.

A summary of SSC safety classifications is provided in Subsection 3.5.3. The classification is based on the accident analysis described in Chapter 13.

The RF and HCF use several inherent safety features that represent good engineering practice for nuclear facilities. Safety-related portions of the RF and HCF are designed to survive the design-basis earthquake and other design-basis events.

As described in Chapter 7a, the reactor protection system is a major contributor to safe operation and shutdown. It is designed to limit operating parameters to preset maximum or minimum values by initiating a scram if limits are exceeded. The system is designed to be fail-safe, defaulting to a shutdown of the reactor for any significant system component failure. The system is designed to restrict operator actions to a prescribed sequence and to permit start-up operation only under proper prescribed reactor parameter conditions. The safety rod and four control rods and their drive systems are designed to provide a rapid and adequate safe shutdown. The safety and control rods are coupled to individual drives by an electromagnet. A scram signal causes an interruption of the electric current to the electromagnet and the rods drop by gravity placing the reactor in a subcritical condition (shutdown). This design affords another safety feature in that a loss of electric power to the RF causes the reactor to scram into a safe shutdown condition.

As described in Chapter 6b, the HCF Zone 1a ventilation system is a safety-related SSC that maintains a negative pressure in the zone with respect to surrounding spaces and the environment. The system is designed such that the exhaust is directed through activated charcoal and high efficiency particulate air (HEPA) filters before release to the outside environment. An exhaust stack is provided for the HCF Zone 1a ventilation system. As shown in Chapter 13b, the exposure to the public for a postulated release via the HCF Zone 1a ventilation system is below the regulatory limits for either a ground level release or an exhaust stack release.

1.2.4.1 Radiological Safety

The Radiation Protection Program is implemented to protect the radiological health and safety of workers and members of the public in compliance with the regulatory requirements in 10 CFR Parts 19, 20, and 70. This program includes an As Low As Reasonably Achievable (ALARA) program, radiation monitoring and surveying, exposure control, dosimetry, contamination control, and environmental monitoring. The Radiation Protection Program is described in Chapter 11.

1.2.5 POTENTIAL ACCIDENTS AT THE FACILITY

Potential events are identified by the application of hazard analysis methodologies to evaluate the design of the facility and processes for potential hazards, initiating events, scenarios, and associated prevention and mitigation controls. An evaluation of potential events, including the maximum hypothetical accident, is summarized in Chapter 13a for the RF and Chapter 13b for the HCF. Chapters 13a and 13b describe the features that prevent and mitigate the potential consequences of accidents.

1.3 GENERAL DESCRIPTION OF THE FACILITY

1.3.1 GEOGRAPHICAL LOCATION

The EIPC site is located on vacant, undeveloped land in the southern half of Lea County, NM, east of the City of Eunice, NM, and near the New Mexico–Texas border. Figure 1.3-1 provides an overview of the project site. The EIPC site is at 32° 25’ 25.44” N latitude, and 103° 5’ 46.14” W longitude.

1.3.2 PRINCIPAL CHARACTERISTICS OF THE SITE

The EIPC project site consists of an undeveloped, approximately 240-ac. (97-ha) parcel of dry, flat rangeland traditionally used for the oil and gas industry and light cattle grazing. The EIPC site is located approximately 1.4 mi. (2.2 km) southeast of the eastern edge of Eunice, NM. The site is located 0.6 mi. (1 km) south of NM-176 and 1.8 mi. (2.9 km) southeast of the intersection of NM Highway 18 and NM-176. The New Mexico–Texas state line is approximately 1.9 mi. (3.1 km) east of the site. Figure 1.1-2 shows the project site and boundary, nearby highways, major facilities, and the nearest municipality within the 5-mi. (8-km) vicinity. Figure 1.3-2 details the EIPC building layout on the project site.

The EIPC site is generally flat with slight undulations in elevation. The area surrounding the EIPC project site consists of undeveloped land. The EIPC site is also located in proximity to several other facilities in the nuclear industrial complex, most notably, the URENCO enrichment plant, approximately 1.3 mi. (2.1 km) to the northeast of the site, and the WCS facility, approximately 2.6 mi. (4.2 km) east-northeast of the site, in Andrews County, TX. Further discussion of principal characteristics of the site is provided in Chapter 2.

1.3.3 PRINCIPAL DESIGN CRITERIA, OPERATING CHARACTERISTICS, AND SAFETY SYSTEMS

The EIPC is licensed under 10 CFR Part 50 and some SSCs within the EMIF are classified as safety-related. Subsection 3.5.3 provides the definition of safety-related. Various layout views showing the arrangement of the EMIF are included in Figures 1.3-3 through 1.3-6, including the basement floor plan view (Figure 1.3-3), the first floor plan view (Figure 1.3-4), the second floor plan view (Figure 1.3-5) and the east elevation view (Figure 1.3-6). The RF and HCF operate independently; however, the transfer canal interfaces between the two facilities as shown in Figure 1.3-6.

1.3.3.1 Principal Design Criteria

Design criteria for the EMIF SSCs are addressed in Section 3.1.

1.3.3.2 Operating Characteristics

The reactor is operated continuously with intermediate short-term (i.e., order of hours) shutdowns to remove and replace targets for processing. Periodic shutdowns for maintenance are anticipated. The operating cycle, starting with the reactor at power is as follows:

a. Reactor is placed in a subcritical condition.
b. Specific irradiated targets are remove from the core and placed in the target transfer basket.

c. Fresh targets are placed in the vacated target positions.
d. Reactor is returned to a critical condition and desired operating power.
e. Irradiated targets are transferred from the RF to the HCF via the transfer canal.

The reactor neutronics and operating characteristics are described in Chapter 4a.

The principal activities in the HCF are the following:

- Irradiated LEU target processing.
- Waste storage.
- Waste shipping.
- Product shipping.
- SNM storage.
- Target fabrication.
- Activation isotope processing.

The operating characteristics of the HCF are described in Chapter 4b.

1.3.3.3 Safety Systems

As described in Chapter 3, the RF safety-related SSCs consist of the concrete reactor pool structure and supporting base mat, transfer canal structure and supporting base mat, the reactor targets, the control rod system, and the reactor protection system.

As described in Chapter 3, the HCF safety-related SSCs consist of the HCF uninterruptible electrical power supply system room, the HCF mechanical equipment room housing the HCF Zone 1a fan/filter trains, and the HCF target processing canyon/waste storage canyon reinforced concrete walls, slabs, and base mat, the HCF Zone 1a ventilation system, SCBs 2-7, and the uninterruptible power supply system (UPSS) for the HCF Zone 1a ventilation system.

1.3.4 ENGINEERED SAFETY FEATURES

The ventilation system for HCF Zone 1a, with filtration and backup power from the HCF UPSS, meets the definition of an engineered safety feature. The ventilation system for HCF Zone 1a is described in Chapter 6b. The UPSS is described in Chapter 8. This is the only engineered safety feature in the RF and HCF.

1.3.5 INSTRUMENTATION, CONTROL, AND ELECTRICAL SYSTEMS

The instrumentation and control (I&C) systems for the RF and HCF monitor and control plant operations during normal and transient conditions.

The purpose of the RF I&C systems is to (1) allow monitoring of the status of the reactor, associated reactor subsystems, and environmental conditions within the RF, (2) control the reactor power by adjusting the reactivity state of the reactor, (3) maintain active features to automatically shut down the reactor if conditions exceed the operating limits for the reactor, and

(4) control the operation of selected components in the reactor subsystems and RF. The RF I&C systems are described in Chapter 7a.

The purpose of the HCF I&C systems is to (1) provide continuity of operation to support the isotope production mission of the HCF facility, (2) provide measurement, display, and annunciation of HCF systems important to safe and efficient operations, and (3) provide annunciation of abnormal conditions to allow for operator intervention to correct the abnormal conditions or safely shut the operation down. The HCF I&C systems are described in Chapter 7b.

Electrical power to the EIPC is divided into three subsystems, normal, backup, and safety-related. Normal electrical power is supplied by high-capacity transmission lines, transformed to utilization voltages, and distributed via a tiered bus system. The backup electrical power is supplied by three (3) standby diesel generators to select loads to support operational activities. These systems are described in Sections 8.1 and 8.2.

The UPSS provides safety-related electrical power to the HCF Zone 1a ventilation system. This UPSS is comprised of safety-related batteries, battery charger, and inverter combination. The HCF UPSS electrical power is supplied to specific loads to support safety-related functions. This system is described in Section 8.3.

1.3.6 COOLING AND OTHER AUXILIARY SYSTEMS

As described in Chapter 4a, the RF contains the all-target, steady-state non-power reactor. The reactor core is operated in an open pool that uses light water as the moderator and coolant. The reactor pool is in the central area in the RF high bay. The large volume of the pool, approximately 101,000 liters (26,700 gallons) of water, excluding the volume in the transfer canal, allows for a large thermal mass during both full-power operations and decay heat removal during shutdown. The reactor pool is cooled using a primary/secondary heat rejection system described in Chapter 5a. The targets within the core are cooled by natural circulation flow through the reactor. A chimney extends up from the top of the core that allows for a well-established flow path through the reactor core.

Ventilation for the RF is provided by the RF high bay ventilation system and the RF general area heating, ventilation, and air conditioning (HVAC) system. Ventilation for the HCF is provided by the HCF ventilation systems and the HCF general area HVAC system. The RF and HCF ventilation systems are described in Sections 9a.1 and 9b.1, respectively.

Equipment and processes related to handling and storage of targets within both the RF and HCF are addressed in Sections 9a.2 and 9b.2, respectively. Additionally, equipment and processes related to handling and storage of byproduct material, source, and special nuclear material are addressed in Section 9a.5.

Fire protection systems and programs are addressed in Section 9a.3. Communications systems are addressed in Section 9a.4. Other auxiliary systems are addressed in Sections 9a.7 and 9b.7.

1.3.7 RADIOACTIVE WASTE MANAGEMENT AND RADIATION PROTECTION

The EIPC implements a Radiation Protection Program to protect the radiological health and safety of its workers. The program complies with the regulatory requirements of 10 CFR Parts

19, 20, and 50. This program includes the elements of an ALARA program, radiation monitoring and surveying, exposure control, dosimetry, contamination control, and environmental monitoring. The Radiation Protection Program is described in Section 11.1

The EIPC implements a Respiratory Protection Program to protect its workers from airborne contamination. This program is described in Section 11.3.

The EIPC manages solids, liquids, and gaseous radioactive waste produced during operation of the facility. The Radioactive Waste Management Program is discussed in Section 11.2.

1.3.8 EXPERIMENTAL FACILITIES AND CAPABILITIES

The EIPC does not contain experimental facilities as described in NUREG-1537 and the ISG Augmenting NUREG-1537.

1.3.9 RESEARCH AND DEVELOPMENT

10 CFR 50.34(a)(8) requires a PSAR provide “An identification of those structures, systems, or components of the facility, if any, which require research and development (R&D) to confirm the adequacy of their design; and identification and description of the R&D program which will be conducted to resolve any safety questions associated with such structures, systems, or components; and a schedule of the research and development program showing that such safety questions will be resolved at or before the latest date stated in the application for completion of construction of the facility.”

A summary description of the Eden Target (Fuel) Qualification Plan (TQP) is presented below.

1.3.9.1 Target Qualification Plan Summary Description

The purpose of the TQP is to provide the basis for the qualification of the reactor target fuel elements, building upon operating experience with conversion from highly enriched uranium (HEU) to LEU-fueled Mo-99 targets in the 1990s, augmented by ongoing and planned R&D activities. The TQP presents a discussion of the key attributes of the proposed target fuel design along with the existing industry knowledge base, and the plan to expand the knowledge base necessary to complete the final design.

1.3.9.1.1 Technical Evaluation

The expected performance of the non-power reactor target fuel components is based, in part, on uranium metal fuel technology developed over the last 70 years of uranium-based fuel studies (Gardner,1955; Angerman, Huntoon, & McDonnell, 1959; McDonnell, Caskey, & Angerman, 2000). More recent applicable experience comes from the transition of HEU to high density LEU for Mo-99 production targets under the National Nuclear Security Administration Global Threat Reduction Initiative program. Much of that Mo-99 experience base is documented in “Low-Enriched Uranium High-Density Target Project: Compendium Report” (Vandergrift, 2016) and its associated reference papers. While the efforts documented were focused upon a successful transition from HEU to high density LEU Mo-99 production targets, many of the target designs that were tested share significant attributes with the proposed target fuel design. For instance, many of the tested targets used annular geometry and nickel-coated LEU foils and were clad with Al tubing and successfully irradiated at similar power levels at research and test reactors worldwide.

While these tests were successfully concluded and supported implementation of high-density LEU targets for production of Mo-99, these targets were viewed as “experiments” by the host reactors and qualified under a less rigorous process than considered appropriate for fuel.

As a result, Eden has utilized a phenomena identification and ranking table process to identify key elements of the fuel performance envelope and ensure that the current state of knowledge is sufficient to meet requirements. Where gaps exist, activities were identified to close those gaps. Eden worked with the United States (U.S.) Department of Energy National Labs through the American Medical Isotope Production Act of 2012. Through this act, Eden negotiated work package agreements with Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12), Argonne National Laboratory (ANL), Los Alamos National Laboratory, and Savannah River National Laboratory to establish the data required for the fuel qualification program and radioisotope extraction and processing..

These efforts include, but are not limited to, the topics listed in Table 1.3-1, specific to Eden’s choice of uranium metal alloy and target subcomponent materials:

1.3.9.1.2 Limitations and Conditions

At this time, Eden has not determined if the initial fuel load will be manufactured by Eden or another qualified fuel supplier. If manufactured by Eden, the facility construction must support that activity. If manufactured elsewhere, the fuel targets will be manufactured to Eden’s specifications, informed by the activities outlined in Table 1.3-1. These fuel targets can then be stored until initial fuel load.

It is anticipated that initial reactor startup testing and commissioning activities will not be conducive to irradiating targets for Mo-99 production needs. As such, it is anticipated that initial fuel targets removed from the reactor will be examined in detail in the HCF to ensure they meet performance specifications.

Table 1.3-1
(Sheet 1 of 4)
Target Qualification Activities

Goal	Scope	Status/Target Date
Expand the current knowledge base for manufacturing uranium foil; [[ ]]PROP/ECI	[[ ]]PROP/ECI	Initial phase is complete.
	[[ ]]PROP/ECI	2026 – 2027
Expand the current knowledge base for the process of plating the uranium alloy foil with an appropriate fission product recoil barrier.	[[ ]]PROP/ECI	Completed in 2025.

Table 1.3-1
(Sheet 2 of 4)
Target Qualification Activities

Goal	Scope	Status/Target Date
Expand the current knowledge base for uranium alloy performance under irradiation via separate effects [[ ]]PROP/ECI	[[ ]]PROP/ECI	Partially completed in 2025. [[ ]]PROP/ECI [[ ]]PROP/ECI
Expand the current knowledge base for target assembly (manufacturing) to [[ ]]PROP/ECI	[[ ]]PROP/ECI	Completed in 2025.

Table 1.3-1
(Sheet 3 of 4)
Target Qualification Activities

Goal	Scope	Status/Target Date
Determine heat transfer characteristics of [[ ]]PROP/ECI	[[ ]]PROP/ECI	Awaiting final thermal conductivity report – 2026
Irradiation testing of a near-prototype target, under conditions [[ ]]PROP/ECI	[[ ]]PROP/ECI	2027 – 2028
[[ ]]PROP/ECI	[[ ]]PROP/ECI	2028 – 2029

Table 1.3-1
(Sheet 4 of 4)
Target Qualification Activities

Goal	Scope	Status/Target Date
Thermal hydraulic testing of [[ ]]PROP/ECI	[[ ]]PROP/ECI	2025 – 2027
Utilizing literature data and advanced FEA techniques, complete a thermal-mechanical model of the [[ ]]PROP/ECI	[[ ]]PROP/ECI	2026 – 2029

Abbreviations: ANL = Argonne National Laboratory | Y-12 = Y-12 National Security Complex | DU = depleted uranium | ORNL = Oak Ridge National Laboratory | HFIR = High Flux Isotope Reactor | CFD = computational fluid dynamics | FEA = finite element analysis

1.4 SHARED FACILITIES AND EQUIPMENT

The EIPC does not share any systems or equipment with facilities not covered by this report. The EIPC includes the following structures:

- EMIF, comprised of the RF and HCF.
- Administration Office Complex.
- Access Control Center.
- Production Office Complex.
- Production Warehouse.

The EMIF includes a single non-power, pool-type reactor located in the RF and the radioisotope production line located in the HCF. The RF portion of the EMIF operates independently from the HCF. The transfer canal, the target transfer system, a wall separating the facilities, liquid effluent control system, and common utilities are shared by the RF and HCF.

1.5 COMPARISON WITH SIMILAR FACILITIES

1.5.1 COMPARISON OF PHYSICAL PLANT AND EQUIPMENT

The EMIF RF contains the all-target, non-power, pool-type reactor that is similar to a traditional Training, Research, Isotopes Production, General Atomics (TRIGA) reactor. However, the all-target reactor has different fuel and core design and no pulse capability. The thermal hydraulic characteristics for pool-type reactors are such that the core is cooled by natural circulation flow. The systems supporting the reactor, including reactivity control, control rod drives, instrumentation, and reactor protection system, are similar to a TRIGA facility.

The EMIF HCF is similar in design to the line at Sandia National Laboratories that was developed for Mo-99 production in the mid-1990s. The modification to the Cintichem process now allows the use of LEU fuel with a modified process developed by ANL (Vandergrift, 2016).

Further discussion of these topics is provided in Chapters 4, 5, 6, and 7.

1.5.2 COMPARISON OF CHEMICAL PROCESSES

Production of Mo-99 can be accomplished by fission of U-235, activation of molybdenum-98, or using a photoneutron reaction process using molybdenum-100. The Mo-99 produced from fission is referred to as “fission moly.” Fission moly is produced by the world suppliers for three reasons:

- Fission moly can be made in copious quantities using the fission process in a nuclear reactor.
- The Mo-99 product has a very high specific activity.
- The major generator companies all load and distribute aluminum-oxide generators that can only be used with high specific activity Mo-99.

The EIPC produces fission moly using the all-target reactor.

There are two chemical processes that can be used for separating Mo-99 from the fission products, actinides, and LEU targets after irradiation in a nuclear reactor. Both processes dissolve the LEU fuel material in a solution and then separate and purify the Mo-99 using radiochemical processes. An alkaline process is used throughout the world to dissolve the complete target, including the LEU and the Al cladding material. The EIPC uses an acidic process that only dissolves the LEU metal foil within the target. The acidic process is used for the following reasons:

- The amount of solution waste produced is minimized.
- The uranium metal dissolution process takes only a few hours to complete.
- The acidic process has been developed and used previously in the United States for commercial applications.
- The uranium extraction (UREX) process can be used with the waste solution to remove the LEU efficiently from the waste stream.

Currently, the world's supply for Mo-99 comes from Europe, South Africa, and Australia. Except for Australia, all others use aging infrastructure and relatively aged, government-owned, high-power research reactors. These producers all use LEU as the target fuel and the alkaline chemical process for dissolution of the target material.

The last commercial producer of fission moly in the United States was Cintichem, Inc. Cintichem used an acidic process to dissolve irradiated HEU oxide-coated targets that had been irradiated in their plate-type fueled reactor and processed in an adjacent hot cell facility. Their operation ceased in 1990. The radiochemical process Cintichem used was originally developed by Union Carbide in the 1960s. The process became known as the Cintichem process.

Two U.S. Nuclear Regulatory Commission (NRC) construction permits have been granted for the production of fission moly in the United States. Northwest Medical Isotopes, LLC (NWMI) received a construction permit in 2018 to build a hot cell and fuel fabrication facility that was to be located near Columbia, Missouri. The production concept was to produce LEU targets that would be irradiated at the Missouri University Research Reactor and shipped back to the NWMI facility for processing using the Cintichem process. The facility was never built, and the construction permit terminated in 2022.

SHINE Technologies, LLC (SHINE) received a construction permit from the NRC in 2016 to build a subcritical reactor and hot cell facility near Janesville, Wisconsin. The production concept involves eight subcritical solution reactors driven individually by accelerators producing 14-megaelectronvolt neutrons. The SHINE facility was issued a final NRC Safety Evaluation Report in 2023. The facility is in the process of being completed, but no production date has been given.

The EIPC uses a modified Cintichem process developed by ANL (Vandergrift, 2016). This process was uniquely developed by ANL for LEU target material and incorporates the Cintichem radiochemical processes. [[

]]PROP/ECI

1.5.3 COMPARISON OF SUPPORT SYSTEMS

Supporting systems, including ventilation, cooling water, waste processing, electrical power, and I&C, are conventional in nature. In general, there are no unique features of the EIPC that warrant discussion in this section. Systems are discussed in detail in the appropriate sections of this report.

1.6 SUMMARY OF OPERATIONS

The major operations to be performed at the EMIF are:

- Fabrication of LEU metal foil targets.
- Irradiation of LEU targets.
- Disassembly, dissolution, separation, purification, packaging, and shipping of the Mo-99, I-131, and Xe-133 from the LEU targets.
- LEU reclamation and recycling for refabrication.
- Waste packaging, storage, and shipment.

Figure 1.6-1 provides a high-level overview of the uranium process flow. More detailed discussion can be found in Chapters 4a and 4b.

The fabrication of the LEU metal foil targets involves heating and rolling LEU metal ingots into foils, applying a nickel recoil barrier coating to both surfaces, and then shaping the foil into a cylinder. An Al cladding is placed on the inside and outside of the LEU foil cylinder and the formed targets are cut to the proper dimensions after which the inner and outer cladding are welded together at each end. Finally, the targets are uniquely identified, marked, and logged. To provide assurance that the targets can be manufactured and safely irradiated at full-power operation for the duration of their lifecycle, a Target Qualification Plan has been developed. Target design and fabrication are discussed in Chapter 4a and 4b.

Irradiation of the LEU targets is performed while the reactor is operated in steady-state mode at a thermal power of 1.8 MWt. The irradiation cycles for the targets may range from 1 to 21 days at full reactor power. Following irradiation, the LEU targets are removed from the reactor and transferred to the HCF via the transfer canal for processing using the target transfer system.

Following a cooling period in the transfer canal, irradiated targets are moved to the HCF target receipt box for processing. Disassembly and dissolution of the LEU metal foil takes place in dissolver units within dissolver boxes. Dissolution of the LEU metal foil is accomplished using nitric acid and [[ ]]$^{PROP/ECI}$. Following evacuation of the dissolver unit, the solution is passed through a titania (titanium oxide) column to separate and collect the Mo-99 from the solution. The Mo-99 is purified in further steps using the modified Cintichem process within a purification box. The product is a highly pure Mo-99 solution that is then moved to the packaging box. In the packaging box, the Mo-99 solution is placed in a shielded shipping container prior to being sent to the product shipping area where it is prepared for shipment. Following separation, the LEU solution is transferred to the UREX box for reclamation and reprocessing via solvent extraction.

After processing, the raffinate is sent to the waste packaging box, where it is neutralized, solidified, and stored in waste drums in the waste storage canyon to allow for a decay period.

1.7 COMPLIANCE WITH THE NUCLEAR WASTE POLICY ACT OF 1982

The EIPC does not produce either high-level nuclear waste or spent nuclear fuel. Therefore, the Nuclear Waste Policy Act of 1982 is not applicable.

1.8 FACILITY MODIFICATIONS AND HISTORY

This report is an application for construction of the EIPC. As there are no existing facilities, there have been no modifications, and there is no history to report in this section. Therefore, this is not applicable to the EIPC.

1.9 REFERENCES

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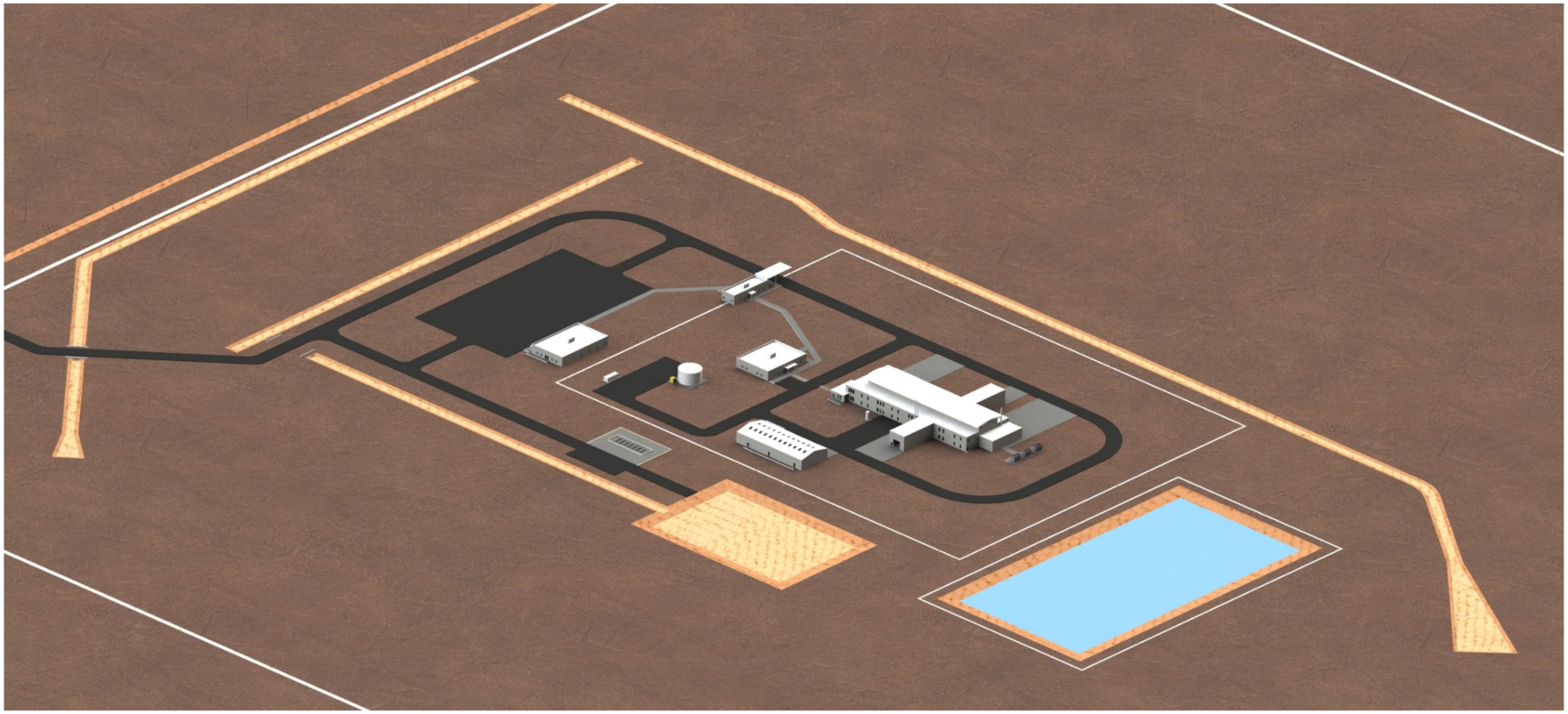
Figure 1.1-1
Visual Rendering of Project Site



View Looking Northeast

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Figure 1.1-2
EIPC Site Vicinity

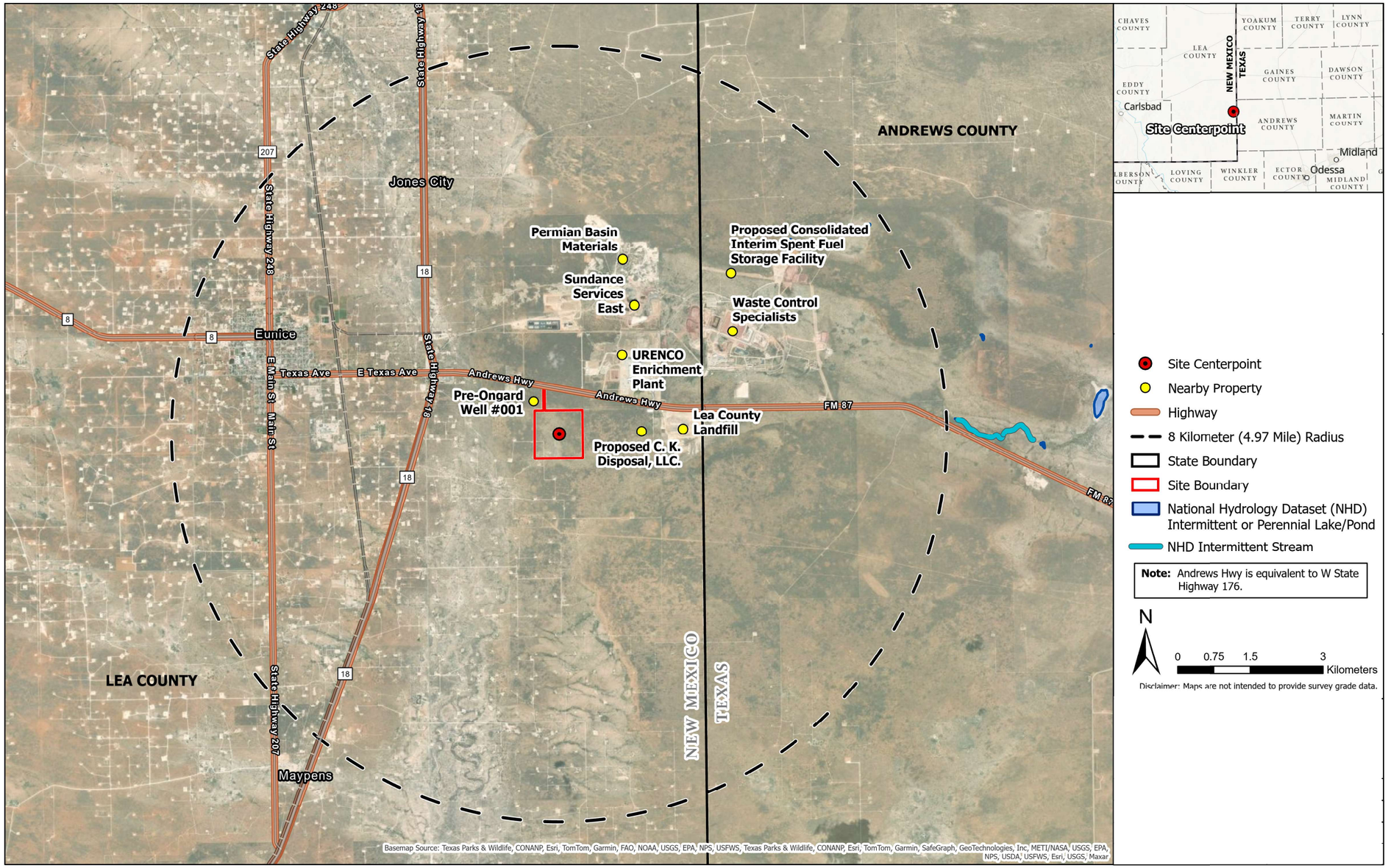

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Figure 1.3-1
EIPC Project Site

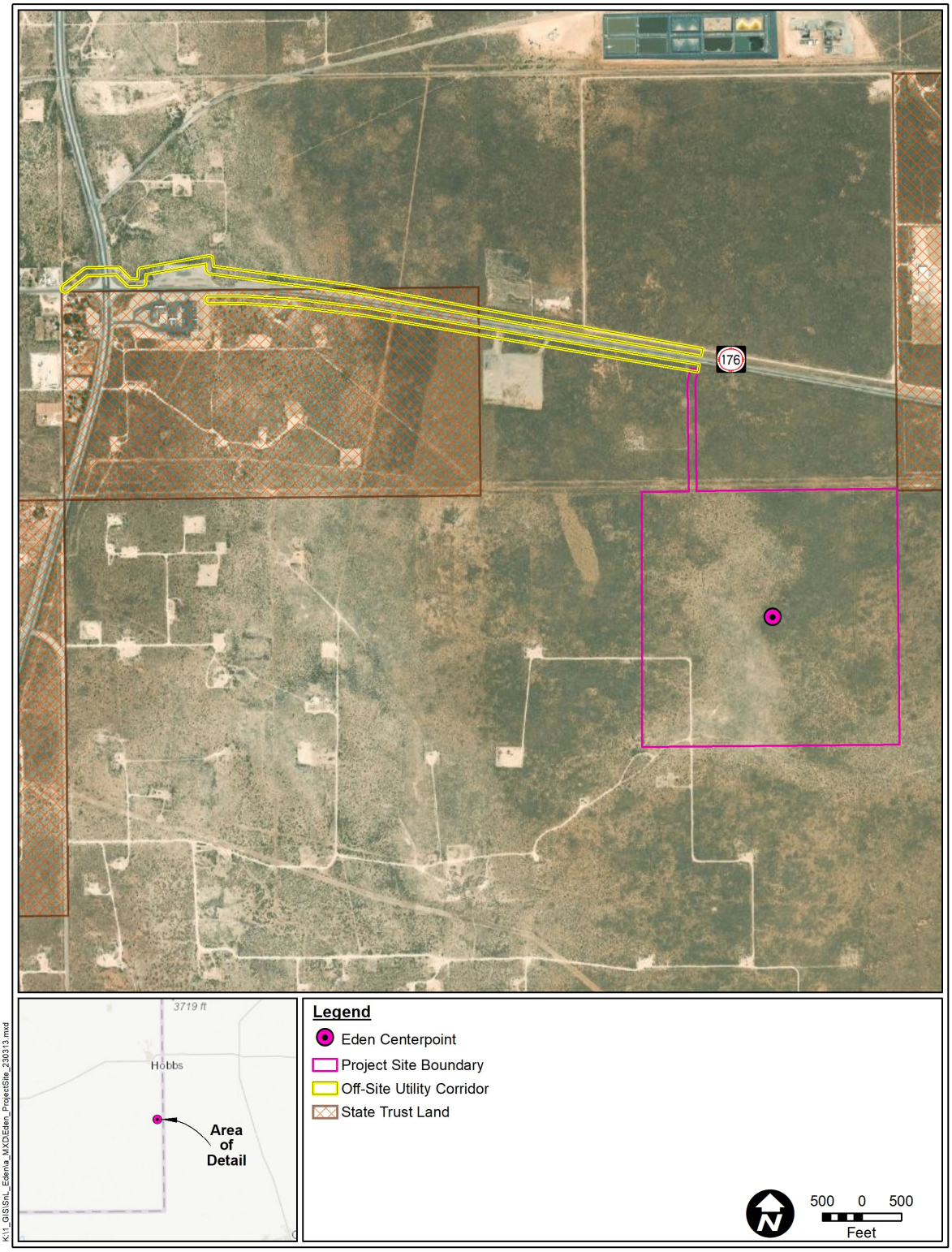
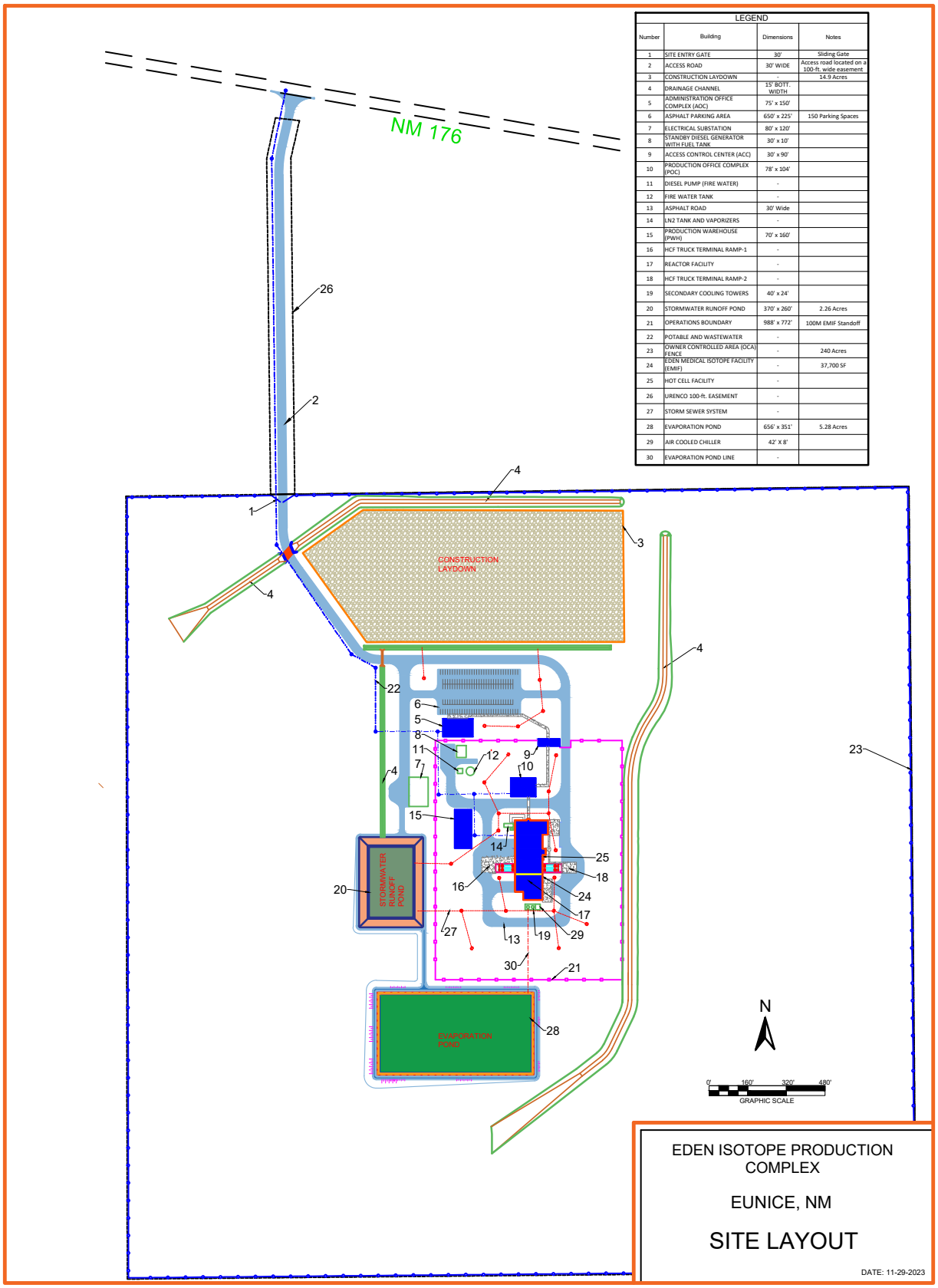


Figure 1.3-2
Eden Isotope Production Complex Building Layout



LEGEND

Number	Building	Dimensions	Notes
1	SITE ENTRY GATE	30'	Sliding Gate
2	ACCESS ROAD	30' WIDE	Access road located on a 100-ft. wide easement
3	CONSTRUCTION LAYDOWN		14.9 Acres
4	DRAINAGE CHANNEL	15' BOTT. WIDTH	
5	ADMINISTRATION OFFICE COMPLEX (ADC)	75' x 150'	
6	ASPHALT PARKING AREA	650' x 225'	150 Parking Spaces
7	ELECTRICAL SUBSTATION	80' x 120'	
8	STANDBY DIESEL GENERATOR WITH FUEL TANK	30' x 10'	
9	ACCESS CONTROL CENTER (ACC)	30' x 90'	
10	PRODUCTION OFFICE COMPLEX (POC)	78' x 104'	
11	DIESEL PUMP (FIRE WATER)	-	
12	FIRE WATER TANK	-	
13	ASPHALT ROAD	30' Wide	
14	LN2 TANK AND VAPORIZERS	-	
15	PRODUCTION WAREHOUSE (PWH)	70' x 160'	
16	HCF TRUCK TERMINAL RAMP-1	-	
17	REACTOR FACILITY	-	
18	HCF TRUCK TERMINAL RAMP-2	-	
19	SECONDARY COOLING TOWERS	40' x 24'	
20	STORMWATER RUNOFF POND	370' x 260'	2.26 Acres
21	OPERATIONS BOUNDARY	988' x 772'	100M EMIF Standoff
22	POTABLE AND WASTEWATER	-	
23	OWNER CONTROLLED AREA (OCA) FENCE	-	240 Acres
24	EDEN MEDICAL ISOTOPE FACILITY (EMIF)	-	37,700 SF
25	HOT CELL FACILITY	-	
26	URENCO 100-ft. EASEMENT	-	
27	STORM SEWER SYSTEM	-	
28	EVAPORATION POND	656' x 351'	5.28 Acres
29	AIR COOLED CHILLER	42' X 8'	
30	EVAPORATION POND LINE	-	

Figure 1.3-3
Eden Medical Isotope Facility Layout – Basement Floor Plan View

[[

]]PROP/ECI/SRI

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Figure 1.3-4
Eden Medical Isotope Facility Layout – First Floor Plan View

[[

]]PROP/ECI/SRI

Figure 1.3-5
Eden Medical Isotope Facility Layout – Second Floor Plan View

[[

]]PROP/ECI/SRI

Figure 1.3-6
Eden Medical Isotope Facility Layout – East Elevation View

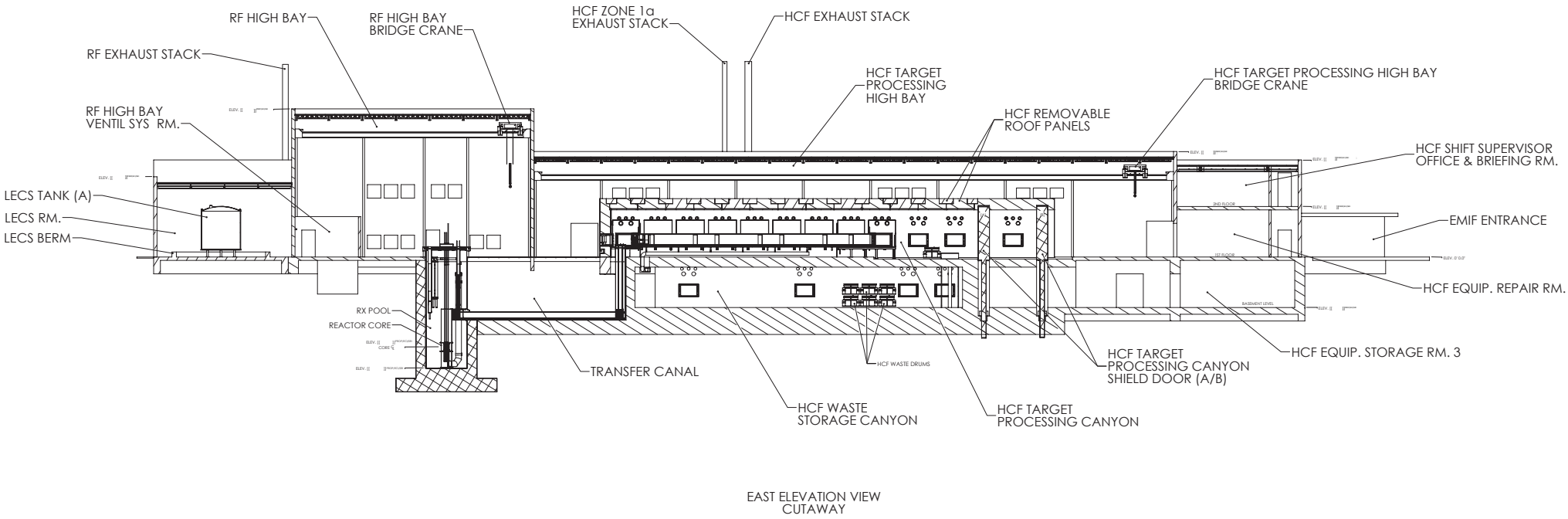

Figure 1.6-1
Eden Isotope Production Complex – Uranium Process Flow

[[

]]PROP/ECI

Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 2
Site Characteristics

eden | Precision Science. Human Impact.

CHAPTER 2
SITE CHARACTERISTICS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
χ/Q	atmospheric dispersion factors
ΔH	heat of combustion
°C	degrees Celsius
°F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
ac.	acre
ac-ft	acre-feet
AEDC	Andrews Economic Development Corporation
ALOHA	Areal Locations of Hazardous Atmospheres (computer program)
ANFO	Ammonium Nitrate/Fuel Oil
AMS	American Meteorological Society
AMSL	above mean sea level
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ASCE	American Society of Civil Engineers
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BLEVE	boiling liquid expanding vapor explosion
BMP	best management practice
B.P.	Before Present
CFR	Code of Federal Regulations

Acronym/Abbreviation	Definition
cfs	cubic feet per second
CISF	consolidated interim waste storage facility
cm	centimeter(s)
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COOP	cooperative observing program
DBT	dry bulb temperature
DRS	Design Response Spectrum
EDCLC	Economic Development Corporation of Lea County
Eden	Eden Radioisotopes, LLC
EF scale	Enhanced Fujita scale
EIPC	Eden Isotope Production Complex
EIS	Environmental Impact Statement
EMIF	Eden Medical Isotope Facility
EPRI	Electric Power Research Institute
EPZ	Emergency Planning Zone
F scale	Fujita scale
FAA	Federal Aviation Administration
FEMA	U.S. Federal Emergency Management Agency
ft.	feet
ft^2	square foot
ft/mi	feet per mile
ft/s	feet per second
g	standard acceleration due to gravity

Acronym/Abbreviation	Definition
GAI	geographic area of impact
gal.	gallon(s)
GCD	Groundwater Conservation District
GHG	greenhouse gas
H_2S	hydrogen sulfide
Ha	hectares
HCF	Hot Cell Facility
hr.	hour(s)
HUC	Hydrologic Unit Code
IIFP	International Isotopes Fluorine Products, Inc.
in.	inch(es)
ISP	Interim Storage Partners, LLC
kg	kilogram(s)
kg/m^2	kilograms per square meter
kg/s	kilograms per second
KHOB	Lea County Regional Airport
km	kilometer(s)
km^2	square kilometer(s)
km^2/y	square kilometer(s) per year
KMAF	Midland International Air and Space Port
KROW	Roswell Air Center
kW/m^2	kilowatts per square meter
L	liter
lb.	pound(s)
lb/ft^2	pound(s) per square foot

Acronym/Abbreviation	Definition
lb/s	pound(s) per second
LCD	local climatological data
LECS	liquid effluent control system
m	meter(s)
m^3	cubic meter(s)
m/km	meters per kilometer
m^3/s	cubic meters per second
m/s	meter/second
MCWBT	mean coincident wet bulb temperature
mi.	mile(s)
mi^2	square miles
mph	miles per hour
NAAQS	National Ambient Air Quality Standards
NAVD88	North American Vertical Datum of 1988
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
NCES	National Center for Education Statistics
NHD	National Hydrography Dataset
NIDIS	National Integrated Drought Information System
NM	New Mexico
NM-18	New Mexico Highway 18
NM-176	New Mexico Highway 176
NMED	New Mexico Environment Department
NMSU	New Mexico State University
NO_2	nitrogen dioxide

Acronym/Abbreviation	Definition
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NWI	National Wetland Inventory
NWS	National Weather Service
O_3	ozone
Pb	lead
PGA	peak ground acceleration
PM	particulate matter
$PM_{2.5}$	particulate matter with aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	particulate matter with aerodynamic diameter less than or equal to 10 microns
PMF	Probable Maximum Flood
PMH	Probable Maximum Hurricane
PMP	Probable Maximum Precipitation
ppm	parts per million
psid	pounds per square inch differential
RF	Reactor Facility
RPS	reactor protection system
RV	recreational vehicle
s	second
s/m^3	seconds per cubic meter
SEI	Structural Engineering Institute
SO_2	sulfur dioxide
SPC	Storm Prediction Center
SPCC	spill prevention, control, and countermeasure plan

Acronym/Abbreviation	Definition
TDC	Texas Demographic Center
TNT	trinitrotoluene
TRS	total reduced sulfur
TX	Texas
UNM	University of New Mexico
URENCO	Urenco, USA
UHRS	Uniform Hazard Response Spectra
U.S.	United States
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
UWB	underground water basin
V-H	vertical-to-horizontal
WBT	wet bulb temperature
WCS	Waste Control Specialists LLC

2. Site Characteristics

2.1 GEOGRAPHY AND DEMOGRAPHY

This section describes the location and important features of the Eden Isotope Production Complex (EIPC) site and vicinity, in conjunction with present and projected population distributions, industrial facilities and land use, and site activities and controls. Site characteristics that are important for design and analysis discussions in other chapters are identified and discussed in this section.

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification and Location

The EIPC site is located on vacant, undeveloped land in the southern half of Lea County, New Mexico (NM), east of the City of Eunice, NM, and near the New Mexico-Texas border. Figure 2.1-1 shows the site location in relation to city, county, and state boundaries.

The project site is approximately 240 acres (ac.) (97 hectares [ha]). The project site has the following coordinates:

Latitude/Longitude (Degrees/Minutes/Seconds)	**Universal Transverse Mercator (meters [m])**	**New Mexico East State Plane Coordinates (feet [ft.])**
North 32° 25’ 25.44” West 103° 5’ 46.14”	North 3,589,000 East 679,011	Northing 520,095.23 Easting 923,087.04

The EIPC site is located approximately 1.4 miles (mi.) (2.2 kilometers [km]) southeast of the eastern edge of Eunice, NM. The site is located 0.6 mi. (1 km) south of New Mexico Highway 176 (NM-176) and 1.8 mi. (2.9 km) southeast of the intersection of New Mexico Highway 18 (NM-18) and NM-176. The New Mexico-Texas state line is approximately 1.9 mi. (3.1 km) east of the site.

The EIPC site is generally flat with slight undulations in elevation. Surrounding properties consist of undeveloped land immediately to the north, east, south, and west. A network of oil wells is present to the immediate south and west of the project site. The EIPC site is also located in close proximity to several other facilities in the nuclear industrial complex, most notably, the Urenco, USA (URENCO) enrichment plant, approximately 1.3 mi. (2.1 km) to the northeast of the site, and the Waste Control Specialists, LLC (WCS) facility, approximately 2.6 mi. (4.2 km) east-northeast of the site, in Andrews County, Texas (TX).

2.1.1.2 Boundary and Zone Area Maps

Highways and railways in close proximity to the EIPC site are also shown in Figure 2.1-1. The figures referenced in this subsection include an arrow indicating true north.

Figure 2.1-2 shows the boundaries and zones applicable to the project site. The controlled area is established in accordance with the American National Standards Institute/American Nuclear Society (ANSI/ANS) 15.7-1977, Research Reactor Site Evaluation (R1896) (ANSI/ANS, 1986); ANSI/ANS-15.16-2015, Emergency Planning for Research Reactors (R2024) (ANSI/ANS,

2024); and Title 10 of the Code of Federal Regulations (10 CFR) Part 20.1003. The project site boundary delineates the extent of the area that is subject to the facility Operating License. Though they are defined differently, the site boundary and the controlled area boundary are coincident. Additionally, the Emergency Planning Zone (EPZ) is coincident with the controlled area boundary and site boundary.

The rectangular area surrounding the project site center point within which all safety-related structures are located gives the approximate location and size of the operations boundary in accordance with ANSI/ANS 15.7-1977 and ANSI/ANS 15.16-2015 (R2020) (ANSI/ANS, 1986; ANIS/ANS, 2024).

Figure 2.1-2 also shows the topography in the vicinity of the EIPC site prior to site development. The project site center point elevation is approximately 3379 ft. (1030 m) North American Vertical Datum of 1988 (NAVD88) above mean sea level (AMSL). The project site and adjacent ground within a radius of approximately 1 mi. (1.6 km) are generally flat and range from 3343 ft. (1019 m) AMSL generally southwest of the project site to 3415 ft. (1041 m) AMSL northeast of the project site.

2.1.2 POPULATION DISTRIBUTION

This subsection provides a description of the current and projected population densities in and around the EIPC site. The current population distribution surrounding the EIPC site was estimated based on the year 2020 United States (U.S.) Census Bureau (USCB) decennial census data (USCB, 2021). Population projections were calculated for the following years:

- The year of calculation (2023), based on 2020 census data.
- The beginning of the requested license period (2024).
- 5 years after the beginning of the requested license period (2029).
- The start of commercial operation (2030).
- Every 10-year operational period (2040, 2050, and 2060).
- The end of the requested license period (2070).

Resident and transient populations around the site are estimated and projected for a circular area with a 5-mi. (8-km) radius measured from the site center point. This area is divided into five distance bands, represented by concentric circles of varying radius, and directional sectors 22.5 degrees wide. The circular area is thus divided into 80 segments. Table 2.1-1 and Table 2.1-2 summarize the distance bands and directional sectors utilized in estimating the population distribution. Figure 2.1-3 presents the distance bands and directional sectors surrounding the EIPC site.

For each segment formed by the distance bands and directional sectors, the resident population was estimated using USCB 2020 census data (USCB, 2021). Transient population was estimated using the best available data for major employers, schools, recreation areas, medical facilities, and lodging facilities as described in more detail in Subsection 2.1.2.2. Transient population data were obtained for 2023 and assumed to represent 2020 population levels.

Future resident and transient population growth in each distance/direction segment was projected using specific growth rates that depend on whether the segment is in Lea County,

NM, or Andrews County, TX. The specific growth rates used in these areas are explained in the following paragraphs.

The University of New Mexico (UNM) Geospatial and Population Studies provides state and county population projections for 5-year intervals from July 1, 2020, to 2040 (UNM, 2022). Future population projections were calculated using the cohort-component method, which involves a review of expected births and deaths and a review of recent net migration. Growth rates were applied to the 2020 Census population estimate for Lea County and used to project populations through 2040. 2040 growth rates were used to project populations between 2040 and 2070.

The Texas Demographic Center (TDC) at the University of Texas at San Antonio provides state and county population projections for the years between 2020 and 2060 using two migration scenario datasets: a 1.0 migration scenario, which assumes the migration rates between 2010 – 2020, and a 0.5 migration scenario, which assumes migration rates half of those between 2010 – 2020 (TDC, 2022). The 0.5 migration scenario dataset was utilized as it is recommended for long-term planning purposes. Future population projections were calculated using the cohort-component method. Growth rates were applied to the 2020 Census population estimate for Andrews County and used to project populations through 2060. 2060 growth rates were used to project populations between 2060 and 2070.

The following subsections describe the resident and transient population distribution surrounding the EIPC site.

2.1.2.1 Resident Population

The permanent residence nearest to the EIPC site was identified through field reconnaissance and examination of aerial photographs. The nearest permanent residence is a house located approximately 1.7 mi. (2.7 km) west-northwest of the project site center point.

Figure 2.1-1 shows municipalities and other features within 5 mi. (8 km) of the EIPC site. According to the 2020 Census, the City of Hobbs, NM, was identified as the nearest population center of more than 25,000 persons. However, given the distance between Hobbs and the Project's examination area, it was not included in the population distribution evaluation. The nearest community is the City of Eunice, NM, located approximately 1.4 mi. (2.2 km) west-northwest of the site center point.

The resident population distribution within 5 mi. (8 km) of the site was computed by overlaying the 2020 Census block group data on the grid shown in Figure 2.1-3 and summing the population of the block group(s) within, or partially intersecting, each segment. The ArcGIS Pro geoprocessing tool "tabulate intersection" was used to calculate the overlapping area (ESRI, 2023). To prepare for the tabulate intersection function, individual segment and block group areas were first calculated in ArcGIS Pro. The tabulate intersection tool was then used to calculate the overlapping area and percentage of each block group that intersected a segment. The overlapping area percentage value was multiplied by the USCB block group population to calculate the proportional block group population within the individual segment. The block group fractions were grouped and summed to calculate a total segment population. Calculations of the proportional value and the segment population calculations were performed in Microsoft Excel (Microsoft Corporation, 2023).

Annualized growth rates for Lea County, NM, and Andrews County, TX, were used to project future populations within each segment, considering the percentage of each segment that each county occupied. All future populations were rounded to the nearest whole number to avoid estimating a fraction of a person.

The population distributions and all related information were collected and the results tabulated for all distances of interest in all 16 directions. The tabulated results show that in 2020, the residential population within 5 mi. (8 km) of the EIPC site was 2703. The resident population for 2020 is shown in Figure 2.1-4 and projections for 2023 through 2070 are shown in Figure 2.1-5 through Figure 2.1-12. Table 2.1-3 also summarizes the resident population and projections for 2020 through 2070.

2.1.2.2 Transient Population

Information concerning transient population for the area within the 5-mi. (8-km) radius surrounding the EIPC site was obtained from a variety of public sources for major places of employment, schools, medical facilities, lodging facilities, and recreational areas. Although most transient populations using these facilities are also likely residents in the area, this information is not definitive as there is no way to determine the overlap between resident and transient population. Therefore, all transient populations were treated as separate from the residential population. Transient populations were estimated based on data obtained from publicly available information, including federal, state, county, and city government websites; federal, state, regional, and local agency websites; corporate websites belonging to employers in the region; tourism websites; and websites that aggregate records of service providers such as lodging facilities. More information is given below on the methods of estimating transient population for each facility type.

Public school district employment was sourced from staff directories on the local school district website. School enrollment data for private and public schools were retrieved from the National Center for Education Statistics (NCES) (NCES, 2023a; NCES, 2023b). Private school employment was calculated based on the listed student-to-teacher ratio and rounded to the nearest whole value to avoid estimating a fraction of a person.

City employee data were sourced from the staff directory on the local municipal website.

Employee counts for industrial employers were sourced, if possible, from company websites. If unavailable, estimates were obtained from the Economic Development Corporation of Lea County (EDCLC, 2023) and the Andrews Economic Development Corporation (AEDC, 2023) economic development websites and from job resource websites (e.g., Buzzfile.com and ZoomInfo.com).

Information about lodging facilities was collected from several sources. Where available, data on accommodations and number of recreational vehicle (RV) hookups were drawn from the website of the facility itself. However, many facilities identified did not have a website or did not publish specific information about facility capacity. Tourism websites, including Hotels.com and Vrbo.com, were also used to source information about facility capacity. For facilities where no data could be acquired using the above sources, Facebook and imagery from Google Maps or Google Image Search were used to estimate the number of rooms or number of RV hookups. Unless otherwise stated on the facility's website, rooms were assumed to be occupied by three people and RV spots and campsites also by three people. For one motel, single cabins were listed as available for reservation and were assumed to be occupied by two people. In another

instance, an RV park's website specified that a maximum of two adults and three children were allowed, for a total of five occupants per RV site. All rooms were assumed to be occupied; this is a conservative assumption.

Visitor data for public recreation areas within 5 mi. (8 km) of the project site were estimated using publicly available imagery and information. In instances where visitor data could not be sourced from publicly available information, parking spaces were counted using aerial imagery and population was estimated assuming that the facility was at capacity and that each vehicle was occupied by three people. Where parking data were not available, images of the facilities themselves and of events at the facilities were assessed to estimate usage when at capacity. Larger city parks with pavilions and sports fields were assumed to have a capacity of 50. Populations at motorsport tracks or rodeo facilities with bleachers were estimated by using a seating capacity formula. It is likely that most users of these types of facilities are residents or tourists visiting the area and thus are captured in census data or estimates of transient populations using lodging facilities.

Table 2.1-4 lists the identified transient population estimates within 5 mi. (8 km) of the project site. The estimates listed represent the total number of people expected to be at the facility for any part of a typical day, with no consideration of the length of time they are likely to be there. To obtain a more accurate representation of the transient population surrounding the EIPC site, the transient population estimates were weighted according to the length of time people could be expected to stay at each facility, assuming typical use patterns for each type of facility. Therefore, the estimates for employers and schools were multiplied by a weighting factor of 0.27, which assumes that each employee or student is present at the facility 9 hours (hr.) per day and 5 days per week. Estimates for recreation areas were multiplied by a weighting factor of 0.33, which assumes that each daily visitor is present at the recreation area 8 hr. per day, 7 days per week. Estimates for lodging facilities were not multiplied by any weighting factor, effectively assuming that each room in a lodging facility is occupied 24 hr. per day and 7 days per week. This is a conservative assumption that is likely to overestimate the normal transient populations at these facilities, but represents the maximum possible population.

Table 2.1-5 summarizes the weighted transient population estimates by facility type for each distance band.

The transient population estimates were assumed to be reflective of 2020. Projected transient populations were computed with the same methodology used to develop the resident population projections. Table 2.1-6 presents the projected weighted transient population estimates for each distance band.

2.1.2.3 Combined Resident and Transient Population

The estimated 2020 and projected resident and weighted transient population values were combined and then projected to obtain an estimate of the total population surrounding the EIPC site. All estimates were rounded to the nearest whole number to avoid estimating a fraction of a person. Table 2.1-7 displays the combined resident and weighted transient population values for all years for each distance band and Figure 2.1-13 through Figure 2.1-21 show the combined populations for all years for their respective distances and directions.

Table 2.1-1
Distance Bands

Distance Band from Site Center Point		
0 to 0.6 mi.	0 to 1 km	0 to 3281 ft.
0.6 to 1.2 mi.	1 to 2 km	3281 to 6562 ft.
1.2 to 2.5 mi.	2 to 4 km	6562 to 13,123 ft.
2.5 to 3.7 mi.	4 to 6 km	13,123 to 19,685 ft.
3.7 to 5.0 mi.	6 to 8 km	19,685 to 26,247 ft.

Abbreviations: mi. = miles | km = kilometers | ft. = feet

Table 2.1-2
Directional Sectors

Direction Name	Central Direction[a]	Symbol
North	0.0°	N
North-northeast	22.5°	NNE
Northeast	45.0°	NE
East-northeast	67.5°	ENE
East	90.0°	E
East-southeast	112.5°	ESE
Southeast	135.0°	SE
South-southeast	157.5°	SSE
South	180.0°	S
South-southwest	202.5°	SSW
Southwest	225.0°	SW
West-southwest	247.5°	WSW
West	270.0°	W
West-northwest	292.5°	WNW
Northwest	315.0°	NW
North-northwest	337.5°	NNW

a) All directional sectors are 22.5° wide, or 11.25° on either side of the central direction.

Table 2.1-3
Resident Population Distribution within 5 Mi. (8 Km) of the EIPC Site Center Point

Distance Band (mi.)	2020	2023	2024	2029	2030	2040	2050	2060	2070
0 to 0.6	0	0	0	0	0	0	0	0	0
0.6 to 1.2	16	16	16	16	16	16	16	16	16
1.2 to 2.5	47	47	47	47	47	63	63	65	65
2.5 to 3.7	1308	1347	1360	1428	1449	1557	1670	1799	1929
3.7 to 5.0	1332	1371	1384	1460	1473	1587	1709	1838	1973
Total	**2703**	**2781**	**2807**	**2951**	**2985**	**3223**	**3458**	**3718**	**3983**

Abbreviations: mi. = miles | km = kilometers

Table 2.1-4
(Sheet 1 of 4)
Estimated Transient Population within 5 Mi. (8 Km) of the EIPC Site Center Point

Sector ID[a]	Facility Type	Facility Name	Distance (mi.)[b]	Transient Population		
				Unweighted[c]	Weight	Weighted
ALL	Airport Facilities	None	-	-	-	-
WNW (5.0)	Lodging	Five Star Inn[d]	3.9	63	1.00	63
WNW (5.0)	Lodging	Oil Patch Motel[e]	4.0	129	1.00	129
WNW (3.7)	Lodging	Desert Oasis RV Park[f]	3.0	1875	1.00	1875
NW (5.0)	Lodging	Finish Line RV Park[g]	4.8	195	1.00	195
WNW (3.7)	Lodging	JD RV Park[g]	3.4	48	1.00	48
WNW (3.7)	Lodging	A.N.A. Rentals[g]	3.6	60	1.00	60
WNW (5.0)	Lodging	Cardinals Nest[h]	4.2	6	1.00	6
WNW (5.0)	Lodging	LG's RV Park[g]	3.9	36	1.00	36
WNW (3.7)	Major Employer	Eunice City Government — Administrative[i]	3.7	3	0.27	1
WNW (5.0)	Major Employer	Eunice City Government — Chamber of Commerce[i]	3.8	1	0.27	0
WNW (3.7)	Major Employer	Eunice City Government — Compliance Department[i]	3.7	1	0.27	0
WNW (3.7)	Major Employer	Eunice City Government — Eunice Public Library[i]	3.7	3	0.27	1
WNW (3.7)	Major Employer	Eunice City Government — Finance Department[i]	3.7	2	0.27	1

Table 2.1-4
(Sheet 2 of 4)
Estimated Transient Population within 5 Mi. (8 Km) of the EIPC Site Center Point

Sector ID[a]	Facility Type	Facility Name	Distance (mi.)[b]	Transient Population		
				Unweighted[c]	Weight	Weighted
WNW (3.7)	Major Employer	Eunice City Government — Fire & EMS[i]	3.7	10	0.27	3
WNW (5.0)	Major Employer	Eunice City Government — Motor Vehicle Department[i]	3.7	1	0.27	0
WNW (5.0)	Major Employer	Eunice City Government — Police Department[i]	4.6	11	0.27	3
WNW (3.7)	Major Employer	Eunice City Government — Public Works[i]	3.7	4	0.27	1
WNW (5.0)	Major Employer	Eunice City Government — Recreation Department Activity Center[i]	4.2	3	0.27	1
WNW (5.0)	Major Employer	Eunice City Government — Recreation Department Aquatic Center[i]	3.8	1	0.27	0
WNW (5.0)	Major Employer	Eunice City Government — Senior Citizen Center[i]	4.6	4	0.27	1
NE (2.5)	Major Employer	URENCO[j]	1.3	231	0.27	62
ENE (2.5)	Major Employer	Waste Control Specialists[k]	2.1	150	0.27	40
WNW (3.7)	Major Employer	Sundance Services West, Inc[l]	3.3	59	0.27	16
W (3.7)	Major Employer	NMR Pipeline, LLC[m]	3.7	62	0.27	17
WNW (5.0)	Major Employer	Parker Energy Support Services[m]	4.5	31	0.27	8
WNW (5.0)	Major Employer	EP&S, LLC[m]	3.9	22	0.27	6
WNW (5.0)	Major Employer	Lowe's Market[m]	3.8	18	0.27	5

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Table 2.1-4
(Sheet 3 of 4)
Estimated Transient Population within 5 Mi. (8 Km) of the EIPC Site Center Point

Sector ID[a]	Facility Type	Facility Name	Distance (mi.)[b]	Transient Population		
				Unweighted[c]	Weight	Weighted
WNW (3.7)	Major Employer	United Energy Transport Services[m]	3.4	15	0.27	4
WNW (5.0)	Major Employer	Dairy Freeze 2[m]	4.1	15	0.27	4
ENE (3.7)	Major Employer	Federal NORM Services, LLC[n]	3.5	12	0.27	3
ALL	Medical Facilities	None	-	-	-	-
WNW (5.0)	Parks and Recreation Areas	Eunice Activity Center[o]	4.2	50	0.33	17
WNW (5.0)	Parks and Recreation Areas	Eunice Aquatic Center[p]	3.8	48	0.33	16
NW (5.0)	Parks and Recreation Areas	Cardinal Speedway[q]	4.8	403	0.33	134
WNW (5.0)	Parks and Recreation Areas	Eunice Cardinal Field/Athletic Complex[r]	4.3	3087	0.33	1029
WNW (5.0)	Parks and Recreation Areas	Marshall Park[s]	3.9	50	0.33	17
WNW (5.0)	Parks and Recreation Areas	Eunice Rodeo Arena[t]	3.9	201	0.33	67
WNW (5.0)	School Facilities	Caton Middle School[u][v]	4.1	190	0.27	51
WNW (5.0)	School Facilities	Eunice High School[v][w]	4.1	265	0.27	71
WNW (5.0)	School Facilities	Mettie Jordan Elementary School[v][x]	4.2	400	0.27	107

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Table 2.1-4
(Sheet 4 of 4)
Estimated Transient Population within 5 Mi. (8 Km) of the EIPC Site Center Point

Sector ID[a]	Facility Type	Facility Name	Distance (mi)[b]	Transient Population		
				Unweighted[c]	Weight	Weighted
WNW (5.0)	School Facilities	Eunice Holiness Academy[y]	4.2	23	0.27	6
ALL	**TOTAL**			**7788**		**4104**

Abbreviations: mi. = miles | km= kilometers | RV = recreational vehicle | EMS = Emergency Medical Services | EDCLC = Economic Development Corporation of Lea County | AEDC = Andrews Economic Development Corporation | NCES = National Center for Education Statistics | URENCO = Urenco, USA

a) Facilities used by transient populations were identified through desktop reconnaissance within 5 mi. (8 km) of the project site center point.
b) Linear distance from facility to the project site center point.
c) Estimated populations assumed to be representative of 2020.
d) Hotel room count sourced from Hotels.com (Hotels.com, 2023). Assumed to contain three people per room.
e) Hotel room and RV hook-up count sourced from Google satellite imagery and Resnexus (Google, 2023; Resnexus, 2023). Single cabins assumed to contain two people per cabin, double rooms assumed to contain three people per room, and RV sites assumed to contain three people per site.
f) RV site count sourced from Desert Oasis RV Park website (Desert Oasis RV Park, 2023). Sites listed to contain a maximum of two adults and three children per site. Sites assumed to contain five people per site.
g) RV site count sourced from Google satellite imagery (Google, 2023).
h) Vacation rental listing sourced from Vrbo.com and listed to allow a maximum six people (Vrbo, 2023). Assumed to contain six people.
i) Employee information sourced from Eunice Municipal Government Staff Directory (City of Eunice, 2023).
j) Employee information sourced from EDCLC (EDCLC, 2023).
k) Employee information sourced from AEDC (AEDC, 2023).
l) Employee information sourced from Buzzfile company profile (Buzzfile, 2023a).
m) Employee information sourced from Buzzfile search results for companies in Eunice, NM (Buzzfile, 2023b).
n) Employee information sourced from ZoomInfo search (ZoomInfo, 2023).
o) Visitor capacity sourced from a City of Eunice memorandum (City of Eunice, 2017).
p) Visitor capacity sourced from satellite imagery of site parking lot spaces. Assumes three people per car.
q) Visitor capacity sourced from satellite imagery of facility bleachers; seating capacity formula ([# Rows x Length of Row in Inches] / Inches of Personal Space per Person) was used to determine bleacher capacities. Assumes 24 inches of personal space per person.
r) Visitor capacity sourced from construction engineering company (Wilson & Company, 2023).
s) Municipal park with pavilions and baseball fields present (Google, 2023). Assumes 50 people.
t) Bleachers present. Satellite imagery suggests they are similar in size to Cardinal Speedway. Assumed to hold the same number of people as one set of Cardinal Speedway's bleachers (Google, 2023).
u) Staff information sourced from Canton Middle School staff directory (Canton Middle School, 2023).
v) Student population information sourced from NCES district page (NCES, 2023a).
w) Staff information sourced from Eunice High School staff directory (Eunice High School, 2023).
x) Staff information sourced from Mettie Jordan Elementary School staff directory (Mettie Jordan Elementary School, 2023).
y) Student population information sourced from NCES school page (NCES, 2023b). Staff information determined by NCES listed teacher-to-student ratio.

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Table 2.1-5
Weighted Transient Populations within 5 Mi. (8 Km) of the EIPC Site Center Point by Distance Band and Facility Type

Distance Band (mi.)	Airport Facilities	Lodging	Major Employers	Medical Facilities	Parks and Recreation Areas	Schools	TOTAL
0 to 0.6	0	0	0	0	0	0	**0**
0.6 to 1.2	0	0	0	0	0	0	**0**
1.2 to 2.5	0	0	102	0	0	0	**102**
2.5 to 3.7	0	1983	47	0	0	0	**2030**
3.7 to 5.0	0	429	28	0	1280	0	**1972**
TOTAL	**0**	**2412**	**117**	**0**	**1280**	**235**	**4104**

Abbreviations: mi. = miles | km = kilometers

Table 2.1-6
Weighted Transient Population Distribution within 5 Mi. (8 Km) of the EIPC Site Center Point, 2020 – 2070

Distance Band (mi.)	2020	2023	2024	2029	2030	2040	2050	2060	2070
0 to 0.6	0	0	0	0	0	0	0	0	0
0.6 to 1.2	0	0	0	0	0	0	0	0	0
1.2 to 2.5	102	105	107	113	114	124	136	147	159
2.5 to 3.7	2030	2094	2115	2217	2238	2414	2592	2781	2986
3.7 to 5.0	1972	2033	2055	2154	2174	2344	2517	2702	2900
TOTAL	**4104**	**4232**	**4277**	**4484**	**4526**	**4882**	**5245**	**5630**	**6045**

Abbreviations: mi. = miles | km = kilometers

Table 2.1-7
Combined Resident and Weighted Transient Population Distribution within 5 Mi. (8 Km) of the EIPC Site Center Point, 2020 – 2070

Distance Band (mi.)	2020	2023	2024	2029	2030	2040	2050	2060	2070
0 to 0.6	0	0	0	0	0	0	0	0	0
0.6 to 1.2	16	16	16	16	16	16	**16**	**16**	**16**
1.2 to 2.5	149	153	154	160	161	187	199	211	224
2.5 to 3.7	3338	3441	3475	3646	3687	3971	4262	4582	4914
3.7 to 5.0	3304	3406	3439	3614	3646	3931	4226	4539	4873
TOTAL	6807	7016	7084	7436	7510	8105	8703	9348	10,027

Abbreviations: mi. = miles | km = kilometers
Note: Table 2.1-7 values are not an exact summation of Table 2.1-3 and Table 2.1-6 due to the projection calculation process. To calculate the values for Table 2.1-7, 2020 resident and weighted transient populations were totaled, and future population was projected based on this value.

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2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY INSTALLATIONS

This section documents current and projected industrial, transportation, and military installations and operations within 5 mi. (8 km) of the EIPC. None of these sources of off-site man-made hazards require a design basis safety evaluation beyond the screening described in the subsections below.

The primary hazard for the EIPC is explosive overpressure that causes damage to safety-related equipment or structures. These explosive overpressures may be due to explosions at the source of the chemical or because of a flammable vapor cloud that is drawn toward the site that may ignite inside site structures.

Additionally, hazards associated with radiative heat transfer onto safety-related structures, the habitability of the reactor control room, and the risk of accidental aircraft impact were evaluated.

A toxic chemical release is considered a low risk to the EIPC because there is no need for continued reactor control room habitability after a toxic chemical release. Therefore, reactor control room habitability following a toxic chemical release is not evaluated. Within the EIPC, the reactor control room is located in the Reactor Facility (RF) adjacent to the RF high bay. The reactor protection system (RPS) automatically scrams the reactor if specific parameter limits are exceeded as described in Chapter 7a. Operator action is not required, there are no additional actions the operator needs to take once the RPS scrams, and continued operator occupation of the reactor control room is not required. The reactor control system is designed to allow the operator to control the reactor within an acceptable envelope during normal operating conditions, including planned transients; however, no operator actions are credited in the safety analysis of postulated events described in Chapter 13a or 13b.

2.2.1 LOCATIONS AND ROUTES

This subsection documents the locations of all off-site man-made hazard sources. For the EIPC, this includes pipelines, wells, truck transport on NM state highways, rail transport, petrochemical processing facilities, and additional facilities that have chemicals on-site. Table 2.2-1 lists all identified sources. The locations of these sources are shown in Figures 2.2-1 through 2.2-4.

2.2.1.1 Nearby Facilities

Figure 2.2-1 shows relevant facilities. Superfund Amendment and Reauthorization Act Tier II reports were collected for all identified facilities within 5 mi. (8 km) of the EIPC.

WCS is a low-level radioactive waste storage and disposal facility. Propane, gasoline, and diesel fuel are the primary chemical hazards located on-site.

URENCO is a uranium enrichment facility. The primary chemical hazards on-site are uranium hexafluoride, diesel fuel, and various lubricating oils.

The Permian Basin Materials Quarry is a blasting location. The facility uses significant amounts of solid explosives. Diesel fuel is also stored at the site. Ammonium nitrate is brought to the quarry and mixed with fuel oil to create Ammonium Nitrate/Fuel Oil (ANFO) for use in blasting.

Love’s Truck Stop is a gas station. The primary chemical hazards on-site are gasoline, diesel fuel, and diesel exhaust fluid.

The Targa Gas Plant processes natural gas to remove impurities for Targa pipelines. As such, many hydrocarbons including methane, propane, ethane, butane, and pentanes are regularly stored on the site. Additionally, the facility has diglycolamine, gasoline, hydrogen sulfide (H_2S), methanol, oils, sulfuric acid, triethylene glycol, and other processing fluids.

The Targa North Compressor Station is a compressor station for Targa pipelines. As such, similar chemicals to the Targa Gas Plant are present at the facility, but in smaller quantities. Given the compressor station is farther from the EIPC, the gas plant bounds instances at the compressor station.

2.2.1.2 Roadways

The two through-traffic roadways evaluated are NM-176 and NM-18, as shown in Figure 2.2-2. State road NM-176 travels east-west through Eunice. It is the most direct road from Eunice to cities in central Texas. However, there are no significant cities to the west in New Mexico. As such, road chemical transportation traffic is expected to be limited to commonly occurring chemicals and chemicals that are used at facilities in Eunice.

State road NM-18 travels north-south through Eunice. It connects cities on the east side of New Mexico with western Texas. However, there are no major metropolitan areas along the route. As such, road chemical transportation traffic is expected to be limited to commonly occurring chemicals and chemicals that are used at facilities in Eunice.

The chemicals that are considered likely to be trucked on either road near the EIPC are propane, gasoline, and solid explosives. These are bounding over other explosive chemicals.

2.2.1.3 Railways

The Texas & New Mexico railway travels north-south through Eunice. Propane and solid explosives are evaluated on the main line. These are bounding hazards for chemicals likely transported on the railway.

A spur runs from the main line to the WCS facility. No flammable or explosive materials are permitted on the spur aside from those used at the WCS facility. Any WCS facility chemical bounds chemicals on the WCS spur.

These railways are shown in Figure 2.2-2.

2.2.1.4 Oil and Gas Wells

There are hundreds of oil wells within 5 mi. (8 km) of the EIPC. The concern for oil wells is a blowout and explosion. Because the make-up of crude oil fluctuates, gasoline releases and explosions are evaluated as bounding for oil wells.

There are dozens of gas wells within 5 mi. (8 km) of the EIPC. The extracted natural gas could result in an explosion at the well or a delayed ignition explosion at the EIPC.

Wells are shown in Figure 2.2-3.

2.2.1.5 Pipelines

There are many pipelines in the vicinity of the EIPC, including gas transmission lines, liquid transmission lines, and natural gas gathering lines. The lines nearest the EIPC contain natural gas, sour gas, or carbon dioxide (CO_2). The liquid lines contain crude oil or liquefied petroleum gases such as propane and butane. These lines are shown in Figure 2.2-4.

2.2.2 AIR TRAFFIC

There are no active airports within 10 mi. (16 km) of the EIPC. There are two airports within 20 mi. (32.2 km) of the EIPC. Methods found in NUREG-1537, Part I, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content, allow for airports at a distance of 10 mi. (16.1 km) to have 51,200 operations annually. Note that methods in NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, are very similar, allowing for airports at a distance of 10 mi. (16.1 km) to have 50,000 operations annually. The two airports between 10 and 20 mi. (16.1 and 32.2 km) from the EIPC, Lea County Regional and Lea County Jal, reported 8856 and 3000 annual operations respectively in their 2024 Federal Aviation Administration (FAA) filings (FAA, 2023a, FAA, 2023b). As a result, airports are not considered a hazard to the site.

In addition to the airports listed in Table 2.2-1, an additional airport west of Eunice, approximately 9 mi. (14.5 km) from the EIPC, is marked on the Albuquerque FAA Sectional chart as “Abandoned – paved having landmark value, 3000 ft. or greater” and is, therefore, not included in additional discussion (FAA, 2024a).

There are two air routes that travel within 10 mi. (16.1 km) of the EIPC. The FAA visual flight rules sectional for Albuquerque and the low altitude instrument flight rules enroute chart show flight path V68 (FAA, 2024a; FAA, 2024b). The high altitude instrument flight rules enroute chart shows flight path Q20 as extending roughly from Hobbs, NM, to Midland, TX (FAA, 2024c). The centers of the flight paths are 6.58 mi. (10.6 km) and 1.65 mi. (2.6 km), respectively, from the EIPC at their closest points. The edge of the V68 airway is 1.98 mi. (3.19 km) from the EIPC center point. The EIPC is within the boundaries of the Q20 airway, which is 8 nautical miles (9.21 statute miles) wide. Figure 2.2-5 shows a map of the flight paths.

The WCS Consolidated Interim Storage Facility (CISF) Safety Analysis Report (Docket No. 72-1050), which considered both Q20 and V68 as traveling over the site, states that the risk to its site from aircraft is 7.38×10^{-7} crashes per year (WCS, 2021). Using a scaling factor based on the WCS and EIPC site areas, the risk associated with the EIPC is estimated to be 3.16×10^{-7} airplane crashes per year. This is less than the acceptance criteria of 10^{-6} airplane crashes per year as documented in the WCS CISF Safety Analysis Report. Therefore, accidental airplane crashes are not a threat to the EIPC.

2.2.3 ANALYSIS OF POTENTIAL ACCIDENTS AT FACILITIES

The facilities and routes identified in Subsection 2.2.1 are evaluated to determine the hazards of:

- An uninhabitable control room due to toxic vapors.
- Damage to EIPC structures due to explosive overpressure from stationary explosions.

- Damage to EIPC structures due to explosive overpressure from delayed ignition explosions.
- Damage to safety-related structures and equipment due to radiative heat transfer.

Subsections 2.2.3.1 through 2.2.3.4 show that none of the chemical sources, and, therefore, none of the facilities and transportation routes, pose a hazard to the EIPC. It is concluded that none of the facilities can affect the reactor. Only off-site hazards are described herein. Potential on-site hazards will be evaluated prior to submittal of the Operating License Application.

Note that some of the distances in this subsection are less than those identified in Table 2.2-1 because bounding analysis are often used for multiple instances of hazards. The values presented in the body text are the analyzed distances, while the values in Table 2.2-1 are the actual distances to each chemical source from the nearest safety-related structure.

2.2.3.1 Control Room Habitability

Control room habitability is not evaluated herein because the EIPC does not require a safety-related control room in a habitability transient, as described in Section 2.2.

2.2.3.2 Explosive Overpressure from Stationary Explosions

Explosive overpressure from stationary sources is calculated using the trinitrotoluene (TNT) equivalence method from Regulatory Guide 1.91, Evaluations of Explosions Postulated to Occur at Nearby Facilities and on Transportation Routes near Nuclear Power Plants, Revision 3. The method relates pounds (lb.) of a chemical to the standoff distance in feet. The acceptance criteria, based on Regulatory Guide 1.91, is that site safety-related structures are expected to withstand an explosive overpressure of 1 pound per square inch differential (psid).

$$R = k \cdot W^{1/3} \qquad \text{(Equation 2.2-1)}$$

$$W = \alpha\, m\, (\Delta H_c / \Delta H_{TNT}) \qquad \text{(Equation 2.2-2)}$$

where:

R is the safe standoff distance in feet.

k is the overpressure coefficient of 45 ft. per $lb.^{1/3}$ for a 1 psid overpressure.

W is the effective weight of TNT in lb.

α is the yield fraction.

m is the mass of explosive chemical in lb.

ΔH_c and ΔH_{TNT} are the heats of combustion for the chemical and TNT in British thermal units per lb.

For chemicals that are gases at standard conditions (e.g., propane and methane), the entire contents of the tank are considered in the explosive mass. For chemicals that are liquids at

standard conditions (e.g., diesel fuel and gasoline), the tank is considered filled with vapor at the upper explosive limit of the chemical.

The yield is set to 100 percent for fully confined explosions per Regulatory Guide 1.91. For releases from pressurized tanks to the atmosphere (e.g., propane and methane), the explosion is not considered fully confined and has a yield of 3 percent (FEMA, 1989).

Using this method, the bounding instances of the following chemicals are evaluated.

Diesel Fuel: Diesel fuel was identified as located at URENCO, WCS, Permian Basin Quarry, and Love's Truck Stop. The maximum amount of diesel fuel is a 40,000-gallon (gal.) (151,000 liters [L]) tank, corresponding to 137 lb. (62 kilogram [kg]) of explosive vapor, located 0.90 mi. (1.4 km) from the EIPC. The maximum allowable mass of explosive diesel vapor at 0.90 mi. (1.4 km) is 119,000 lb. (54,000 kg). Therefore, diesel fuel tanks are not a hazard to the EIPC.

Solid Explosives: Solid explosives are evaluated on roads, railways, and at the Permian Basin Quarry. As noted in Section 2.2.1.1, ammonium nitrate is shipped to the quarry for use in creating ANFO. Ammonium nitrate and ANFO have smaller heat of combustion than TNT. To be conservative the analysis assumes the solid explosive is TNT. The maximum allowable mass of TNT at 0.44 mi. (0.71 km), less than the distance from the nearest road to the EIPC, is 137,000 lb. (62,000 kg), which is greater than the quantity of ANFO at the quarry at any one time. Per RG 1.91, the maximum probable quantity of solid explosive in a railcar is 132,000 lb. (60,000 kg) and 50,000 lb. (22,700 kg) in a highway truck. Therefore, solid explosives are not a hazard to the EIPC.

Gasoline: Gasoline was identified at many facilities and on roadways. The maximum amount of gasoline in a single tank is 28,000 gal. (106,000 L), corresponding to 81.1 lb. (37 kg) of explosive vapor, located on the roadway. The maximum allowable mass of explosive gasoline vapor at 0.44 mi. (0.71 km) is 13,200 lb. (6000 kg). Therefore, gasoline tanks are not a hazard to the EIPC.

Methanol: Methanol was identified at Targa Resources Eunice Gas plant. The maximum amount of methanol in a single tank is 25,000 lb. (11,300 kg), corresponding to 14 lb. (6.4 kg) of explosive vapor. The maximum allowable mass of explosive methanol vapor at 0.90 mi. (1.4 km) is 267,000 lb. (121,000 kg). Therefore, methanol tanks are not a hazard to the EIPC.

Natural Gas: Natural gas was identified at Targa Resources Eunice Gas plant. Natural gas is evaluated as methane. The maximum amount of natural gas or methane in a single tank is 500,000 lb. (227,000 kg). The maximum allowable mass of methane at 0.90 mi. (1.4 km) is 3,530,000 lb. (1,600,000 kg). Therefore, permanent storage of natural gas is not a hazard to the EIPC. Pipelines are considered for delayed ignition explosions in Subsection 2.2.3.3.

Propane: Two bounding instances of propane are evaluated. First, 50,000-lb. (23,000 kg) trucks of propane are evaluated. At a distance of 0.44 mi. (0.71 km), the maximum allowable mass of propane is 445,000 lb. (202,000 kg). Therefore, propane trucks are not a hazard to the EIPC. Larger quantities of propane exist at other facilities, specifically up to 500,000 lb. (227,000 kg) at Targa Resources Eunice Gas plant. At a distance of 0.9 mi. (1.4 km), the maximum allowable mass of propane is 3,810,000 lb. (1,730,000 kg). Therefore, permanent storage of propane is not a hazard to the EIPC.

For chemicals that are gases at standard conditions but are stored as a pressurized liquid, such as propane, a boiling liquid expanding vapor cloud explosion (BLEVE) is also evaluated. A BLEVE pressure wave occurs because of the energy release as the liquid isentropically flashes to gas. The mass fraction that flashes is calculated by setting the entropy equal before and after the expansion. The energy release is then calculated by comparing the internal energy before and after flashing. This energy is used in the TNT equivalence equations to determine a standoff distance for a 1 psid overpressure. BLEVE overpressures are typically less than combustion overpressures for flammable chemicals.

A BLEVE of 50,000 lb. (23,000 kg) of propane has a standoff distance of 0.07 mi. (0.11 km) and a BLEVE of 500,000 lb. (227,000 kg) of propane has a standoff distance of 0.14 mi. (0.22 km).

2.2.3.3 Explosive Overpressure from Delayed Ignition Explosions

Delayed ignition explosions occur when a chemical vapor is released and is transported via the wind toward the site. A flammable vapor cloud at the EIPC may be drawn into site structures and explode, damaging safety-related equipment. As a result, the acceptance criterion for delayed ignition explosions is that the concentration of a chemical vapor cloud must be below the lower explosive limit when the cloud reaches the EIPC. NUREG-0014, Safety Evaluation Reports Related to Construction of Hartsville Nuclear Plants Unit A1, A2, B1 and B2, concluded that detonation of unconfined vapor clouds is not credible. Unconfined means there are no buildings, forests, or other significant obstructions.

The concentration is calculated using the computer program Areal Locations of Hazardous Atmospheres (ALOHA), developed by the U.S. Environmental Protection Agency (USEPA). The meteorological conditions used are those that cause a concentration of a chemical that is exceeded less than 5 percent of the time. As a result, the meteorological conditions used are Pasquill Stability Class F, a wind speed of 3 meters per second (m/s) (6.71 miles per hour [mph]), and a temperature of 97 degrees Fahrenheit (°F) (36 degrees Celsius [°C]).

Natural Gas: For the bounding fixed tank of 500,000 lb. (227,000 kg) of natural gas or methane, the standoff distance to the lower explosive limit is 0.8 mi. (1.3 km). This is less than the standoff distance to natural gas sources. Therefore, permanent storage of natural gas is not a hazard to the EIPC. The nearest natural gas pipeline is 0.18 mi. (0.29 km) from an EIPC structure. A large release of natural gas results in vapor clouds that buoyantly rise. The peak concentration was determined near the top of the highest EIPC structure, approximately 60 ft. (18.3 m), as this is the closest point to the plume centerline. Higher release rates give greater plume rise. Thus, a full pipe break does not represent the worst-case and a variety of release rates were evaluated. It was determined that the highest concentration at the site structure occurs for a release rate of 750 pounds per second (lb/s) (340 kilograms per second [kg/s]). At this worst-case release rate, the concentration at the EIPC is 1.4 percent. This is less than the lower explosive limit of 3.8 percent for natural gas. Therefore, natural gas pipelines are not a hazard to the EIPC.

Gasoline: Gasoline has a high vapor pressure, which results in rapid evaporation. A release of 28,000 gal. (106,000 L), or 162,000 lb. (74,000 kg), of gasoline has a safe standoff distance of 0.45 mi. (0.72 km) to the lower explosive limit. This is less than the distance to the nearest road, where gasoline trucks would be expected to have a mass of 50,000 lb. (23,000 kg), and significantly less than the distance to any source of gasoline larger than 50,000 lb. (23,000 kg). Therefore, gasoline vapor clouds are not a threat to the EIPC.

Methanol: The vapor pressure of methanol is less than that of gasoline. The ALOHA model finds that the concentration of a vapor cloud from an evaporating pool of 25,000 lb. (11,300 kg) of methanol is only a threat directly above the pool. The vapor cloud is not flammable downwind. Therefore, methanol vapor clouds are not a threat to the EIPC.

Propane: Two tanks of propane are evaluated for flammable vapor clouds. The concentration in a vapor cloud following a 50,000-lb. (23,000-kg) truck release reaches the lower explosive limit at 0.35 mi. (0.56 km), which is less than the distance from the nearest road to the EIPC. The concentration in a vapor cloud following a 500,000-lb. (227,000-kg) tank release reaches the lower explosive limit at 0.82 mi. (1.3 km), which is less than the distance from the Targa Resources facility to the EIPC. A release from an 8-inch (in.) (0.2-m) pipeline containing propane has a standoff distance of 0.59 mi. (0.95 km) to the lower explosive limit. To be conservative, the pipeline is modeled as a 500,000 lb. (227,000 kg) tank with an 8-in. (0.2-m) hole because this is the largest tank of chemicals stored at the Targa plant where the pipeline originates. The standoff distance of 0.59 mi. (0.95 km) is less than the distance from the nearest liquid pipeline to the EIPC. Therefore, propane vapor clouds are not a threat to the EIPC.

Butane: A release from an 8-in. (0.2-m) pipeline containing butane has a standoff distance of 0.45 mi. (0.72 km) to the lower explosive limit. To be conservative, the pipeline is modeled as a 500,000 lb (227,000 kg) tank with an 8-in. (0.2-m) hole because this is the largest tank of chemicals stored at the Targa plant where the pipeline originates. The standoff distance of 0.45 mi. (0.72 km) is less than the distance from the nearest liquid pipeline to the EIPC. Therefore, butane vapor clouds are not a threat to the EIPC.

Ethane: A release from an 8-in. (0.2-m) pipeline containing ethane has a standoff distance of 0.37 mi. (0.60 km) to the lower explosive limit. To be conservative, the pipeline is modeled as a 500,000 lb (227,000 kg) tank with an 8-in. (0.2-m) hole because this is the largest tank of chemicals stored at the Targa plant where the pipeline originates. The standoff distance of 0.37 mi. (0.60 km) is less than the distance from the nearest liquid pipeline to the EIPC. Therefore, ethane vapor clouds are not a threat to the EIPC.

2.2.3.4 Radiant Heat Intensity

Two types of radiant heat sources are evaluated. First, following a BLEVE described in Subsection 2.2.3.2, there is often a large mass of highly energetic flammable gas. This gas can rapidly burn in a BLEVE fireball, releasing a high intensity but short duration radiant heat load. Second, a pipeline or tank can rupture in a way that causes a jet fire. This is a steady state but lower intensity heat load. Both BLEVE fireballs and jet fires are modeled using the computer program ALOHA.

The acceptance criteria for safety-related concrete walls come from NUREG/CR-3330, Vulnerability of Nuclear Power Plant Structures, to Large External Fires, which includes a table of allowable heat flux as a function of time.

The worst case BLEVE fireballs are propane trucks and propane tanks at facilities. A BLEVE from a 50,000-lb. (23,000 kg) truck of propane at a distance of 0.44 mi. (0.71 km) has a fireball with a heat flux of 4.71 kilowatts per square meter (kW/m^2) for 14 seconds (s). A BLEVE from a 500,000-lb. (227,000 kg) tank of propane at a distance of 0.9 mi. (1.4 km) has a fireball with a heat flux of 2.55 kW/m^2 for 20 s. NUREG/CR-3330 states that a 15 kW/m^2 heat flux can be withstood for 11.6 hr. Therefore, BLEVE fireball heat fluxes are considered negligible.

The worst-case jet fire is from the natural gas line that is 0.18 mi. (0.29 km) from the EIPC; which is conservative relative to the actual distance from the closest gas pipeline to the RF and Hot Cell Facility (HCF) Using a conservative natural gas release rate from a 15-in. (0.38 m) inner diameter pipe at the highest identified pipe pressure, the heat flux at the EIPC is 8.85 kW/m^2. NUREG/CR-3330 indicates that a 15 kW/m^2 heat flux can be withstood for 11.6 hr. Thus, the facility could withstand a heat flux of 8.85 kw/m^2 for a longer time. Given the conservative nature of this determination and the time available to isolate a rupture, it is reasonable to expect that the jet fire is isolated before the RF or HCF are impacted. Therefore, jet fires are not hazardous to the EIPC.

Table 2.2-1
Potential Hazard Sources

Type	Source	Analyzed Distance
Facility	Waste Control Specialists	2.09 mi.
Facility	URENCO Facility	0.90 mi.
Facility	Permian Basin Materials Quarry	1.25 mi.
Facility	Love's Truck Stop #760	1.41 mi.
Facility	Targa Resources Eunice Gas Plant	2.72 mi.
Facility	Targa Resources Eunice North Compressor Station	4.23 mi.
Road	NM-176 Highway	0.45 mi.
Road	NM-18 Highway	1.70 mi.
Railroad	Texas & New Mexico Railway	2.55 mi.
Railroad	WCS Spur	1.32 mi.
Well	Well Pad near Gas Well 30-025-09936	0.97 mi.
Well	Oil Well 30-025-22768	0.44 mi.
Pipeline	LEA / Fullerton 16 TXBLK A 32A37 SUR 11121	0.18 mi.
Pipeline	Hobbs West Gathering Dollarhide Lateral Loop	2.01 mi.
Pipeline	West Texas LPG System 23373 / Saunders	0.61 mi.
Airport	Lea County Regional	18.83 mi.
Airport	Lea County Jal	19.86 mi.
Federal Airway	Q20 Centerline	1.65 mi.
Federal Airway	V68 Centerline	6.58 mi.

Abbreviations: mi. = miles | URENCO = Urenco, USA | NM-176 = New Mexico Highway 176 | NM-18 = New Mexico Highway 18 | WCS = Waste Control Specialists

2.3 METEOROLOGY

2.3.1 GENERAL AND LOCAL CLIMATE

EIPC is located in eastern Lea County, NM, near the New Mexico-Texas state line. The project site center is located approximately 1.3 mi (2.1 km) southwest of the URENCO uranium enrichment facility and 2.6 mi. (4.2 km) southwest of the WCS site, a radioactive waste disposal facility.

Interim Storage Partners, LLC (ISP) submitted a license application to the Nuclear Regulatory Commission (NRC) for a CISF at the nearby WCS site. The NRC prepared an environmental impact statement (EIS) in support of the CISF, NUREG-2239, Environmental Impact Statement for Interim Storage Partners LLC's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Andrews County, TX. Due to the proximity of the CISF to the EIPC, portions of the EIS are briefly summarized and incorporated by reference in this subsection where applicable.

Meteorological parameters from weather stations in the EIPC climate region are available from a number of published data sources. Those data sources are described below.

- Digital records from the National Weather Service (NWS) cooperative observing program (COOP).

  COOP stations are operated by volunteer observers. These stations record parameters of particular interest to agricultural, industrial, and engineering applications. Depending upon the station, those parameters include daily high and low dry bulb temperatures (DBTs), liquid precipitation, and snowfall.

  COOP stations do not generally record humidity-related parameters, such as relative humidity, dew point, or wet bulb temperatures (WBTs). Therefore, WBTs that are coincident with extreme DBTs, which are of interest in regional climate analysis, are generally not available from COOP stations. Meteorological data from cooperative observers are available from the National Centers for Environmental Information (NCEI) (NCEI, 2022a).

- Digital records and other reports from automated surface weather observing system (ASOS) stations.

  ASOS may be operated by the NWS, the National Oceanic and Atmospheric Administration (NOAA), FAA, or other agencies. Hourly meteorological data files are available in TD-3505 format (NCEI, 2011; NCEI, 2022a). Daily summaries are available from NCEI (NCEI, 2022b).

- Annual and monthly local climatological data (LCD) summaries from NCEI.

  LCD annual summaries are typically available for meteorological stations located at major airports and select automated weather stations. Those summaries include climatic normals, averages, and extremes. Thirty-year monthly histories are generally provided for the following parameters: mean temperature, total precipitation, total snowfall, and heating/cooling degree days. The summaries also include the number of days with reports of specific weather phenomena, including thunderstorms and fog. The summaries also

include a narrative description of the local climate. Monthly LCDs contain much of the same type of information as annual LCDs but are focused on a particular month of a specific year.

Current LCDs are available for the automated weather observing stations at the Midland International Air and Space Port, TX, (station identifier KMAF; NCEI, 2023a) and Roswell, NM (station identifier KROW; NCEI, 2023b).

- Statistical summaries of climatological data from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) (ASHRAE, 2021).

  ASHRAE provides climatic information for worldwide locations, including many U.S. airports and other locations with hourly surface weather observing stations. Parameters include DBTs, WBTs, and dew point temperatures. Also included are statistical design values of dry bulb with mean coincident wet bulb temperature (MCWBT); design WBT with MCDBT; and design dew point with mean coincident DBT. ASHRAE also provides a methodology and key inputs for estimating extreme DBTs and WBTs for various return intervals.

- American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) structural design standards (ASCE/SEI, 2017).

  The ASCE/SEI standards provide minimum load requirements for the design of buildings and other structures that are subject to building code requirements. Particularly useful are maps of 100-year, mean return-interval 3-s wind gusts. ASCE also provides maps of 50-year return interval ground snow load and a methodology for converting 50-year values extracted from those maps to other return intervals.

- 100-year return-interval, 48-hr. duration liquid equivalent precipitation.

  The 100-year return-interval, 48-hr. duration liquid equivalent precipitation is available for the EIPC from NOAA (NOAA, 2023).

- Tornado and other weather event statistics from NCEI's online storm events database and "Storm Data" publications.

  The storm events database contains a chronological listing, by state and county, of climate statistics. Those statistics describe tornadoes, thunderstorms, hail, lightning, high winds, snow, temperature extremes, and other weather phenomena. Also included are statistics on personal injuries and property damage estimates (NCEI, 2022c).

  The "Storm Data" publications are monthly summaries of severe weather events published by NCEI. These publications provide details about specific severe weather events.

- Air quality summaries and air quality monitor data from the USEPA.

  The USEPA provides maps and summaries of the current compliance status of counties with the National Ambient Air Quality Standards (NAAQS), (USEPA, 2022a).

  The agency also provides digital summaries of measured concentrations and related parameters from air quality monitors (USEPA, 2022b). Concentrations from the monitors are used to assess compliance with the specific NAAQS.

2.3.1.1 Description

The EIPC site is in the high plains near the New Mexico-Texas border. The region experiences four seasons and generally low precipitation levels. The regional weather is dominated in the winter by a high-pressure system in the western U.S. and in the summer by a low-pressure system over Arizona. Winters are generally not severe, with temperatures only occasionally dropping below freezing. Summers are typically hot with low relative humidity levels, per NUREG-2239.

2.3.2 LOCAL METEOROLOGY

2.3.2.1 Site Meteorological Data

Climatological parameters are presented in the following subsections. For the purposes of identifying a climate region with meteorological stations relatively close to the EIPC and subject to the same general climatic influences, this analysis concentrates on the three counties surrounding the EIPC: Lea County in New Mexico and Andrews and Gaines counties in Texas.

Table 2.3-1 lists the six COOP stations and the lone automated station relatively closest to the EIPC. Figure 2.3-1 shows the locations of the stations listed in Table 2.3-1.

The ground elevations shown in Table 2.3-1 are listed in meters AMSL because that is the measurement used by NOAA for describing the automated and COOP stations; however, the elevations in meters AMSL are functionally equivalent to NAVD88 elevations used elsewhere in this report.

As shown in Table 2.3-1, and as noted above, six of the seven stations are COOP stations. As described in Subsection 2.3.1, COOP stations generally measure only daily temperature extremes and precipitation totals.

The other meteorological station is an automated station located at Lea County Regional Airport (KHOB), approximately 20 mi. (32 km) northwest of the EIPC (Figure 2.3-1). KHOB measures wind speed/direction, temperature, cloud cover, relative humidity, and precipitation. Hourly weather observations from KHOB are publicly available from NWS (NWS, 2022).

Summaries of meteorological parameters measured at KHOB are available from the NCEI (NCEI, 2022b). The neighboring CISF uses data from the KHOB station, per NUREG-2239. Parameters measured during the most recent full 5-year period (2017 – 2021) are summarized and compared with parameters reported by ISP in Table 2.3-2 (ISP, 2021).

Table 2.3-2 shows average DBTs from KHOB for 2017 – 2021 and corresponding historical values for 1981 – 2020 from NUREG-2239. Average daily temperatures from KHOB for 2017 – 2021 are consistent with historical values; however, Table 2.3-2 shows that average monthly precipitation values for 2017 – 2021 are lower than those reported by NUREG-2239. The generally lower average monthly precipitation values for 2017 – 2021 reflect drought conditions recorded in the region during the period (NIDIS, 2022).

There is regulatory precedent for using airport data as an alternative to on-site meteorological data for reactor siting. Section 2.4.1 of NUREG/CR-2239, Technical Guidance for Siting Criteria Development, states “NWS data have several potential advantages over reactor site data in that they are generally of higher quality, are readily available, contain more detailed observations,

and are of durations up to 30 years." To select KHOB, parameters such as wind speeds, wind directions, temperature and precipitation were investigated for temporal and geographical representativeness.

KHOB is located in the same geographic area as EIPC and satisfies the geographical representativeness criteria, and the comparison of temperature and precipitation to historical data is discussed below.

2.3.2.1.1 Air Flow

As discussed in Subsection 2.3.2.1, the closest meteorological station with publicly available wind speed and direction data is KHOB. A wind rose from the Hobbs weather station for 2010–2015 is provided by NUREG-2239. The predominate wind direction is from the south-southeast.

A wind rose for the full 5-year period (2017 – 2021) at KHOB from NCEI is shown in Figure 2.3-2 (NCEI, 2022d). The most frequent wind direction is from the south to south-southeast, which is consistent with the wind rose from NUREG-2239. The EIPC uses meteorological data from KHOB to support operations. Data from the airport station KHOB are available from NWS (NWS, 2022).

2.3.2.2 Severe Weather

Lea, Andrews, and Gaines counties experience a variety of severe weather events. The NCEI storm events database was queried to extract statistics on severe weather in the three-county area during 1950 – 2022 (NCEI, 2022c). This updates the severe weather climatology provided through 2017 from NUREG-2239. Severe weather events through 2022 are listed in Table 2.3-3. Additional details are provided in the following subsections.

2.3.2.2.1 Tornadoes

Tornado intensity is classified according to the enhanced Fujita tornado intensity scale (EF scale). This scale matches the wind speeds to the degree of observed damage according to 28 indicators. Measuring tornadoes from EF1 to EF5, the EF scale uses more specific structural damage indicators than the original Fujita tornado intensity scale (F scale), which was established in 1971 (SPC, 2022). Table 2.3-4 shows the original F scale and EF scale for reference.

The NCEI storm events database was queried to extract statistics on tornadoes observed in the three-county area during 1950 – 2021 (NCEI, 2022c). Those tornadoes are summarized by their intensity in Table 2.3-5. Tornadoes with a rating of F2/EF2 – F5/EF5 are considered strong to violent. Of the 155 tornadoes recorded in the three-county area during the 71-year period, 139 were included in the lowest-severity categories (F0/EF0 and F1/EF1). The three-county area has experienced two F3/EF3 tornadoes during the 71-year period. This represents the most severe category of tornado experienced in the three-county area.

The NCEI storm events database was queried to extract statistics on regional tornadoes observed within 50 mi. (80 km) of the EIPC during 1950 – 2021 (NCEI, 2022c). Observed strong-to-violent (F2/EF2 – F5/EF5) intensity storms are summarized in Table 2.3-6. A total of 36 tornadoes of intensity F2/EF2 or greater were observed, four of which were of F3/EF3 intensity. This represents the most severe category of tornado experienced within 50 mi. (80 km) of the EIPC.

2.3.2.2.2 Thunderstorms

Thunderstorms are relatively frequent in the summer; they are accompanied by lightning and hail. When hail falls over an agricultural area, considerable crop damage may result (NMSU, 2023). Lightning and hail frequencies are described in the following subsections.

2.3.2.2.3 Lightning

The NCEI storm events database was queried to extract statistics on observed lightning events in the three-county area around the EIPC during 1950 – 2021 (NCEI, 2022c). A total of three events of sufficient intensity to cause fatalities, injury, and/or significant property damage were reported during 1950 – 2021.

The mean frequency of lightning strikes to earth is estimated via a method from the Electric Power Research Institute (EPRI), per the U. S. Department of Agriculture (USDA) Rural Utilities Service (USDA, 1998). The mathematical relationship is as follows:

$$N = (0.31)(T) \qquad \text{(Equation 2.3-1)}$$

where:

T = average number of thunderstorm days per year.

N = number of lightning strikes to earth per square mile per year

Current published values of the average number of thunderstorm days per year are available for the Midland International Air and Space Port in Texas and Roswell in New Mexico (NCEI, 2023a; NCEI, 2023b). The Midland International Air and Space Port is located approximately 61 mi. (98 km) southeast of the EIPC, and Roswell is located approximately 103 mi. (166 km) northwest of the facility.

The number of lightning strikes to earth per square mile per year is computed for Roswell and Midland International Air and Space Port in Table 2.3-7. The average number of thunderstorm days per year at Midland International Air and Space Port is 34.5, which is higher than the value of 29.2 days for Roswell (NCEI, 2023a; NCEI, 2023b). Using the higher of the two values, the estimated frequency of lightning strikes to earth per square mile per year at the EIPC is 10.7 (4.2 strikes per square kilometer per year [km^2/y]).

For comparison, the 10-year period from 2009 to 2018 indicates two-to-four flashes per (km^2/y) around the EIPC (Vaisala, 2018). The EPRI value, therefore, is shown to be a reasonable indicator.

2.3.2.2.4 Hail

The NCEI storm events database was queried to extract statistics on observed hail in the three-county area around the EIPC for 1950 – 2022 (NCEI, 2023c). As shown in Table 2.3-8, approximately 57 percent (490 out of 865 events) did not produce hailstones larger than 1 in. (2.54 centimeters [cm]) in diameter. During 1950 – 2022, 75 hail events with hailstones larger than 2 in. (5.08 cm), seven hail events with hailstones larger than 3 in. (7.62 cm), and eight hail events with hailstones larger than 4 in. (10.16 cm) were documented. The largest hailstone recorded during the period (5 in. [12.70 cm]) was observed in Gaines County on May 22, 1973.

The hail was associated with a storm system that produced multiple reports of large hail in western Texas (NCEI, 1973).

2.3.2.2.5 High Winds

Relatively strong winds often accompany occasional frontal systems during the late winter and spring and may occur in advance of thunderstorms. Winds associated with frontal systems may exceed 30 mph (13.4 m/s) for several hours and reach peak speeds exceeding 50 mph (22.4 m/s). Blowing dust and soil erosion may result during dry periods. Strong winds often accompany thunderstorms that occasionally produce high, damaging winds (NMSU, 2023). Occurrences of high winds in the three-county area are summarized in Table 2.3-3.

2.3.2.2.5.1 100-Year Return-Interval Wind Gust

ASCE standard ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures, provides site-specific 100-year mean return-interval wind gusts (ASCE/SEI, 2017). The 100-year, mean return-interval 3-second gust wind speed at 33 ft. (10 m) above ground level (Exposure Category C) for the EIPC is 90 mph (40 m/s) (ASCE/SEI, 2017; Figure CC.2-4).

2.3.2.2.6 Heavy Rain

Summer rains fall almost entirely during brief, but frequently intense, thunderstorms. The general southeasterly circulation from the Gulf of Mexico brings moisture for these storms into New Mexico, and strong surface heating, combined with orographic lifting as the air moves over higher terrain, causes air currents and condensation. July and August are the wettest months over most of New Mexico, with approximately 30 – 40 percent of the annual total precipitation falling during those months (NMSU, 2023). Statistics on heavy rain events in the three-county area are summarized in Table 2.3-3.

Precipitation extremes are available from the COOP and automated monitoring stations near the EIPC. The stations were identified in Subsection 2.3.2.1.

Table 2.3-9 presents the maximum recorded daily (calendar day) liquid equivalent precipitation from the monitoring stations from NCEI (NCEI, 2022a). The maximum recorded daily liquid equivalent precipitation is 10.53 in. (26.74 cm) at Pearl, NM. The event occurred during July 20 – 21, 1975. NCEI describes the event as follows:

> *Lea County: Continuous heavy rain with storm totals in excess of four inches blocked railroads and highways. Pooling water damaged many houses (NCEI, 1975).*

2.3.2.2.6.1 100-Year Return-Interval, 48-Hr. Duration Liquid Equivalent Precipitation

Point estimates of precipitation return intervals are available from NOAA (NOAA, 2023). Based on the location of the RF building, the 100-year return-interval, 48-hr. duration liquid equivalent precipitation is 7.27 in. (18.47 cm).

2.3.2.2.7 Snow and Ice

Winter precipitation is caused mainly by frontal weather systems associated with the general movement of Pacific Ocean storms across the country from west to east. As these systems move inland, much of the moisture is precipitated over the coastal and inland mountain ranges

of California, Nevada, Arizona, and Utah. Much of the remaining moisture falls on the western slope of the Continental Divide and over northern and high central mountain ranges. Winter is the driest season in New Mexico except for the portion west of the Continental Divide. This dryness is most noticeable in the Central Valley and on the eastern slopes of the mountains of New Mexico (NMSU, 2023).

2.3.2.2.7.1 Snowfall

Table 2.3-9 presents maximum recorded daily (calendar day) snowfall at the local meteorological stations from NCEI (NCEI, 2022a). The maximum recorded daily snowfall for all the stations is 15.0 in. (38.1 cm) at Nadine 2E in New Mexico; this was recorded on January 9, 2012. Table 2.3-9 also shows a maximum daily snowfall of 11.0 in. (27.9 cm) at Hobbs in New Mexico, which occurred on January 10, 2012. The heavy snowfall at both stations was associated with an upper-level storm system with high amounts of atmospheric moisture that moved through western Texas (NCEI, 2012).

2.3.2.2.7.2 100-Year Return-Interval Ground Snow Load

ASCE/SEI 7-16 (Figure 7.2-1 and Table 7.2-6) provides the 50-year ground snow load for locations in New Mexico. Hobbs, NM, is the closest location with a published value. The 50-year ground snow load at Hobbs, NM, is 10 pounds per square foot (lb/ft^2) (48.8 kilograms per square meter [kg/m^2]) (ASCE/SEI, 2017).

ASCE/SEI 7-16 (Section C7.3.3) provides a factor of 1.22 for estimating a 100-year return interval ground snow load from a 50-year ground snow load. The resulting 100-year ground snow load is 12.2 lb/ft^2 (59.6 kg/m^2) (ASCE/SEI, 2017).

2.3.2.2.7.3 Ice Storms

The NCEI storm events database was queried to extract statistics on observed ice storm events in the three-county area around the EIPC during 1950 – 2022 (NCEI, 2022c). Ice storms are defined as events producing ice accretions of 0.25 in. (0.64 cm) to 0.5 in. (1.27 cm) or more (NWS, 2021). A total of 19 events were observed.

The attendant formation of glaze from an ice storm on terrestrial objects creates hazards. Glaze is a coating of ice, generally clear and smooth, formed on exposed objects (AMS, 2012). Tattelman and Gringorten estimated glaze and wind loads for eight regions (I – VIII) of the contiguous U.S. (Tattelman and Gringorten, 1973). The estimates were based on observed ice storms in which the maximum ice thickness of 2.5 cm (1 in.) or more and 5 cm (2 in.) or more occurred during a 50-year period. The state of New Mexico is in Region VIII, which includes all states along and west of the Continental Divide.

Only three ice storms met the criteria for their study in Region VIII. Due to this small sample size, estimates of maximum glaze thickness are not provided for Region VIII, including the state of New Mexico. For locations in Region VIII, Tattelman and Gringorten recommend use of estimated glaze thickness from Region III (New England), the most severe conditions documented in their study, as bounding values for glaze thickness. For Region III, the estimated maximum ice thickness is 5.8 cm (2.3 in.) for a 25-year return period and 7.2 cm (2.8 in.) for a 50-year return period (Tattelman & Gringorten, 1973; Table 6).

ASCE/SEI 7-16 (Figure 10.4-2) provides an estimate of ice thickness and concurrent 3-second wind gusts for a 500-year recurrence interval using the ASCE/SEI 7-16 standard. The 500-year ice thickness at the EIPC is approximately 1 in. (2.54 cm), and the concurrent 3-second wind gust is 40 mph (17.9 m/s) (ASCE/SEI, 2017).

ASCE/SEI 7-16 (Table C10.4-1) provides multipliers for adjusting the 500-year ice thickness and concurrent wind gust to other recurrence intervals. The multipliers for ice thickness and wind pressure for a 25-year recurrence interval are 0.40 and 1.0, respectively; thus, the 25-year ice thickness and concurrent wind gust is 0.40 in. (1 cm) and 40 mph (17.9 m/s) (ASCE/SEI, 2017).

2.3.2.2.8 Heavy Fog

Heavy fog is defined as the occurrence of fog reducing the horizontal visibility to 0.25 mi. (0.40 km) or less (NCEI, 2023a). Occurrences of heavy fog are available for Midland, TX and Roswell, NM.

Table 2.3-10 summarizes the average number of days per month with heavy fog observed at Midland, TX and Roswell, NM (NCEI, 2023a; NCEI, 2023b). At Midland, heavy fog was observed for an average of 14.5 days per year and occurred most often during January and December. At Roswell, NM, heavy fog was observed for an average of approximately 11.6 days per year and most frequently during January and December, a similar annual trend to that observed at Midland, TX.

2.3.2.2.9 Extreme Dry and Wet Bulb Temperatures

2.3.2.2.9.1 Design Dry and Wet Bulb Temperatures

Design basis DBTs and WBTs are defined for the EIPC. They include the following temperatures:

- Maximum DBT with an annual exceedance probability of 0.4 percent.
- MCWBT at the 0.4-percent DBT.
- Maximum DBT with an annual exceedance probability of 1.0 percent.
- MCWBT at the 1.0-percent DBT.
- Maximum DBT with an annual exceedance probability of 2.0 percent.
- MCWBT at the 2.0-percent DBT.
- Minimum DBT with an annual exceedance probability of 1.0 percent.
- Minimum DBT with an annual exceedance probability of 0.4 percent.
- 100-year return maximum annual DBT.
- 100-year return maximum non-coincident annual WBT.

Design temperatures for all the above are available from ASHRAE (ASHRAE, 2021). Design temperatures for Midland, TX, are listed in Table 2.3-11.

The 100-year return-interval maximum annual DBTs and WBTs were estimated using a technique described by ASHRAE (ASHRAE, 2021). The technique estimates the n-year return-interval extreme maximum or minimum temperature using the mean and standard deviation of a series of annual maximum and minimum temperatures. This technique uses the following equation:

$$Tn = M + I\,F\,s \qquad \text{(Equation 2.3-2)}$$

where:

Tn = *n*-year return period value of the extreme DBT to be estimated, years.

M = mean of annual extreme maximum or minimum DBTs, °F.

I = 1 if maximum DBTs are being considered; -1 if minimum DBTs are being considered.

S = standard deviation of annual extreme maximum or minimum DBTs, °F.

n = return period in years (*n* = 100 for a 100-year return interval).

F = Equation 2.3-3.

$$F = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{n}{n-1}\right)\right]\right\} \qquad \text{(Equation 2.3-3)}$$

where:

F is a function that converts the standard deviation of annual extreme temperature parameters (such as the annual extreme temperature) to a new variable that is linearly related to the *n*-year return-interval extreme temperature *Tn*.

ASHRAE provides the mean annual extreme maximum and mean annual extreme minimum temperature (*M*) and the corresponding standard deviations (*s*) in Equation 2.3-2 for the Midland International Air and Space Port in Texas (ASHRAE, 2021).

The inputs, computed 100-year return interval maximum annual DBTs, and non-coincident WBTs computed for the Midland International Air and Space Port from Equation 2.3-2 and Equation 2.3-3 are listed in Table 2.3-12.

2.3.2.2.9.2 Record Dry Bulb Temperatures

An additional review of regional extreme DBTs is done using local meteorological stations. The stations are listed in Table 2.3-1, and their respective locations are shown on Figure 2.3-1.

Table 2.3-13 presents record DBTs recorded at the local weather stations. Table 2.3-13 shows that the overall extreme DBTs are a maximum of 118°F (47.8°C) recorded on June 28, 1994, in Ochoa, NM, and a minimum of -11°F (-23.8°C) recorded at KHOB on February 1, 1951, as well as at Pearl, NM, on both February 1, 1951, and January 29, 1948.

2.3.3 SITE METEOROLOGY

2.3.3.1 Air Quality

2.3.3.1.1 Atmospheric Stagnation

Major air pollution episodes are typically a result of persistent surface high-pressure weather systems that cause light and variable surface winds and stagnant meteorological conditions for four or more consecutive days. Estimates of the stagnation frequency are provided by NOAA, (NOAA, 1999; Figure 1 and Figure 2). Those estimates indicate that, on average, the EIPC experiences approximately 50 days with stagnation per year. When occurring, stagnation lasts approximately 6 days.

2.3.3.1.2 Mixing Heights

The mixing height is the height to which vigorous turbulence tends to mix pollutants (AMS, 2012). Periods of atmospheric stagnation and/or low mixing heights would create adverse atmospheric dispersion condition if a release should occur. Mixing heights vary during the day due to convection caused by daytime heating of the surface. Holzworth (Figure 1 and Figure 6 and Appendix B) estimated monthly mean maximum heights at Midland, TX (Table 2.3-14) that represent approximate seasonal and annual estimates of mixing heights for the EIPC Site (Holzworth, 1972). The estimated lowest average mixing heights (approximately 400 m – 450 m [1310 ft. – 1480 ft.]) generally are recorded during the morning hours, and the highest readings (approximately 2000 m – 2100 m [6600 ft. – 6900 ft.]) are recorded during the afternoon. Seasonally, the lowest average mixing heights occur during winter (290 m [951 ft]) and conversely the highest mixing heights occur during summer (696 m [1988 ft]).

2.3.3.1.3 Ambient Air Quality Standards

The Clean Air Act requires the USEPA to set NAAQS for pollutants considered harmful to public health and the environment. It identifies two types of NAAQS. Primary NAAQS provide public health protection, including that of sensitive populations, such as asthmatics, children, and the elderly. Secondary NAAQS provide public welfare protection, including that against decreased visibility and damage to animals, crops, vegetation, and buildings (USEPA, 2022a).

The USEPA has set NAAQS for six criteria pollutants: ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), lead (Pb), and particulate matter (i.e., PM_{10} and $PM_{2.5}$ – particles with nominal aerodynamic diameters less than or equal to 10 and 2.5 microns, respectively). The criteria pollutants and their respective NAAQS are listed in Table.2.3-15 (USEPA, 2022a). Areas with pollutant concentrations greater than these standards are designated as non-attainment areas. Non-attainment areas may include counties or portions of surrounding counties.

States may impose stricter ambient air quality standards than the NAAQS. New Mexico has additional ambient air quality standards for CO, NO_2, SO_2, H_2S and total reduced sulfur (TRS) (USEPA, 2011a). These additional standards for New Mexico are listed in Table 2.3-16.

The New Mexico Environment Department (NMED) is responsible for issuing permits and enforcing compliance with environmental regulations and standards, including air quality standards. The EIPC complies with applicable regulations.

2.3.3.1.4 Regional Air Quality

Lea County in New Mexico is part of the Pecos-Permian Basin Intrastate Air Quality Control Region (USEPA, 2011b). Air quality monitors measure concentrations of criteria pollutants to demonstrate attainment with the respective NAAQS. The closest air quality monitoring station to the EIPC is located in Hobbs, NM. This monitoring station is operated by the NMED. The monitor measures NO_2, O_3, and $PM_{2.5}$.

Lea County, NM, is designated as attainment for all criteria pollutants (USEPA, 2022c). The closest area designated as non-attainment with one or more NAAQS is Howard County, TX. A portion of Howard County is not in attainment for the 1-hr. SO_2 NAAQS (USEPA, 2022c). Howard County is located approximately 80 mi. (130 km) east of the EIPC.

Criteria pollutant emissions aggregated at the county level from NUREG-2239 are provided in Table 2.3-17 for Lea County in New Mexico, and Andrews and Gaines counties in Texas. The emissions include contributions from stationary and mobile sources. Table 2.3-17 provides pollutant levels that characterize the existing ambient air quality conditions.

The Clean Air Act defines Class I areas as national parks greater than 6000 ac. (2430 ha); wilderness areas greater than 5000 ac. (2020 ha); national memorial parks greater than 5000 ac. (2020 ha); and international parks that were in existence as of August 1977. These areas are potentially sensitive to visibility impairment. The USEPA states that a Class I visibility impact analysis is necessary for a major source within 100 km (62 mi.) of a Class I area (USEPA, 1990).

The USEPA promulgated the Regional Haze Rule to improve visibility in Class I areas in 1999 with the ultimate goal of restoring natural background visibility by 2064 (Federal Register, 1999). This rule was amended in 2005 to require certain industrial facilities to install emission controls to reduce emissions of air pollutants that reduce visibility (USEPA, 2022d; Federal Register, 2005). These pollutants include $PM_{2.5}$ and compounds that contribute to $PM_{2.5}$ formation, such as nitrogen oxides, SO_2, certain volatile organic compounds, and ammonia.

Table 2.3-18 lists the nearest mandatory (federal) or American Indian Class I areas to the EIPC (USEPA, 2022d; NPS, 2022a). The table shows three Class I areas:

- Carlsbad Caverns National Park, approximately 88 mi. (142 km) west of the proposed facility.
- Guadalupe Mountains National Park, about 112 mi. (180 km) west-southwest of the proposed facility.
- Salt Creek Wilderness Area, approximately 113 mi. (182 km) northwest of the proposed facility.

2.3.3.1.5 Greenhouse Gases

Greenhouse gases (GHGs), which can absorb heat in the atmosphere, are produced by numerous sources, including burning fossil fuels and agricultural and industrial processes. Global GHG emissions are estimated to be 49 billion tons (gigatons) of carbon dioxide equivalent (CO_2e) and have been consistently rising in recent decades (Edenhofer, et al., 2014). Global energy-related CO_2 emissions grew in 2022 by 0.9 percent, or 321 million tons, reaching a new high of more than 36.8 gigatons (IEA, 2023). Present-day CO_2 concentrations in the

atmosphere are around 415 parts per million (ppm). By the year 2100, these levels are expected to range from 450 to 936 ppm (USGCRP, 2017).

At the national level, in 2021, U.S. net GHG emissions totaled 6340.2 million metric tons (7088.1 million short tons) of CO_2e, or 5586.0 million metric tons (6157.5 million short tons) of CO_2e after accounting for sequestration from the land sector. Net GHG emissions in the U.S. increased in 2021 by 6 percent compared with 2020 levels due to increased economic activity after the COVID-19 pandemic, but have decreased 17 percent from 2005 levels (USEPA, 2023). The recent decline is mostly due to a shift to less CO_2-intensive natural gas for generating electricity and a rapid increase in the use of renewable energy in the electric power sector (EIA, 2022).

2.3.3.1.5.1 Federal Regulations

In 2010, the USEPA promulgated the Tailoring Rule to address GHG emissions under the Clean Air Act permitting programs. As initially promulgated, the Tailoring Rule specified that new sources, as well as existing sources, with the potential to emit more than 100,000 tons per year CO_2e were subject to USEPA permitting requirements. Modifications of existing facilities that increase GHG emissions by at least 75,000 tons per year are also subject permitting requirements. Subsequent revisions to the Tailoring Rule have not resulted in different GHG emission thresholds, per NUREG-2239.

2.3.3.1.5.2 State of New Mexico GHG Regulations

In 2022, the New Mexico state legislature considered a bill in to achieve “net zero” GHG emissions by 2050 (New Mexico State Legislature, 2022a). This bill did not pass (New Mexico State Legislature, 2022b). However, the ultimate course of any successors to this proposed legislation is uncertain.

The EIPC complies with federal and state environmental regulations related to emissions of GHGs and other regulated pollutants.

Site preparation, construction, operation, and decommissioning of the EIPC are expected to result in emissions of CO_2 and other GHGs through various mechanisms, primarily from combustion of fossil fuels in mobile and stationary sources.

2.3.3.2 Local Data Source

2.3.3.2.1 Local NWS Station

The Hobbs, NM, NWS meteorological station (KHOB) is used to further characterize the regional climate. This station, located about 32 km (20 mi.) north of the proposed EIPC, is the closest NWS meteorological station. It sits at latitude 32.68°N, longitude 103.22°W, and elevation: 3658 ft. (1115 m). KHOB has an Automated Weather Observing System, Type III (AWOS III) that measures temperature, dew point, altimeter setting and wind speed, gusts and direction, as well as visibility, precipitation accumulation (rain gauge), and cloud height. Hourly weather observations from the Lea County Regional Airport are publicly available from NWS (NWS, 2022).

The FAA Advisory Circular describes the FAA standard for procurement, construction, installation, activation, and maintenance of non-Federal AWOS systems (FAA, 2017).

Specifications from this Advisory Circular are listed in Table 2.3-19. On-site instrument calibration is required annually unless more frequent calibration is specified by the FAA region. Calibrations are required to be done by a qualified technician with FAA verification authority and witnessed by a qualified FAA non-Federal inspector. Facilities Maintenance Log and Technical Performance Record forms are maintained. In addition, the NCEI (formerly the National Climatic Data Center [NCDC]) subjects surface meteorological data collected at AWOS stations such as KHOB to documented quality assurance and analysis procedures (Del Greco et al., 2006).

2.3.3.3 Plans to Access Local Meteorological Data during License Period

Meteorological measurements must be available for use in responding to accidental radiological releases or other emergencies and for other routine purposes that require access to meteorological information during the licensing period. That meteorological information is obtained from local government weather monitoring stations that observe wind and other surface meteorological parameters on an hourly basis.

When needed during an emergency, real-time hourly surface meteorological measurements of wind direction, wind speed, air temperature, and weather type are accessible by EIPC through government data sources:

- Internet access to hourly surface weather observations recorded at the KHOB AWOS, at URL: http://www.weather.gov/data/obhistory/KHOB.html.
- If weather observations are not available from the KHOB AWOS, then weather information from another station with hourly meteorological data in the Site Climate Region can be used. The following stations can be accessed:
    - Midland, TX: URL: http://www.weather.gov/data/obhistory/KMAF.html.
    - Roswell, NM: URL: http://www.weather.gov/data/obhistory/KROW.html.

2.3.4 ACCIDENTAL RELEASE SCENARIO

This subsection addresses short-term dispersion modeling approaches for assessing the relative concentration values (χ/Qs) to evaluate dose consequence of postulated releases resulting from accidents.

A Gaussian plume model is used to determine the ground level concentration of a radioactive material in air at a downwind location, normalized by the release rate of the material from the source facility. The short-term dispersion modeling uses the following equation from Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Revision 1, for a stack release without fumigation conditions or building wake effects:

$$\chi/\mathrm{Q} = \frac{1}{\pi U \sigma_y \sigma_z} e^{\left(\frac{-h_e^2}{2\sigma_z^2}\right)} \qquad \text{(Equation 2.3-4)}$$

where:

U = windspeed at the stack release height, in m/s

σ_y = lateral plume spread – a function of the atmospheric stability and distance, in m

σ_z = vertical plume spread – a function of the atmospheric stability and distance, in m

h_e = effective stack height, in m: $h_e = h_s - h_t$

h_s = initial height of the plume (usually the stack height) above plant grade, in m

h_t = maximum terrain height above plant grade, in m. If h_t is greater than h_s, then $h_e = 0$.

The direction component of the wind is not uniquely defined in Equation 2.3-4. The wind direction is not considered for accidental releases at the EIPC. Instead, it is conservatively assumed that the wind direction is always constant towards the receptor at the site boundary.

The expansion of a plume during downwind transport is directly affected by the stability class. The plume dimensions for short distances (1 km [0.6 mi.]) have been experimentally determined over flat terrain covered by prairie grass for short duration plumes (Haugen, 1959). Pasquill used this data to develop curves that represent the change in the plume dimensions (σ_y and σ_z) with downwind distance from a stack for each of the six Pasquill-Gifford Stability classes (A-unstable through F-stable). Pasquill extended the experimental data by extrapolation to 100 km (62.1 mi.) (Pasquill, 1961). These curves were later modified by Gifford (Gifford, 1975; Gifford, 1976). Analytical fits to the Pasquill-Gifford curves were developed by Tadmor and Gur as power law functions having the form:

$$\sigma_y = ax^b \qquad \text{(Equation 2.3-5)}$$

and

$$\sigma_z = cx^d \qquad \text{(Equation 2.3-6)}$$

where:

x = distance to the maximally exposed individual, in m

a – d = empirical constants given in Table 2.3-20

Using Equations 2.3-4 through 2.3-6, the χ/Qs are calculated using an F-stability, 3.3 feet per second (ft/s) (1 m/s) wind speed, which represents a conservative bound on the downwind dose (Tadmor and Gur, 1969). A stack height of 49.2 ft (15 m) is used in the dispersion modeling for a stack release scenario. A ground release scenario is also considered. No building wake effects, exhaust velocity, or surface roughness effects are used.

For the downwind dose calculations in Chapter 13, it is assumed that a member of the public is either at a distance of 600 m (1969 ft.) from the 15-m (49-ft.) exhaust stack representing the peak value for χ/Q for a stack release, or at a distance of 500 m (1640 ft.) for a ground release for the duration of the accident release. A χ/Q of 4.07E-04 seconds per cubic meter (s/m^3) for the stack release and 1.91E-03 s/m^3 for a ground release is determined using the dispersion

model described in this subsection. For comparison, a ground release at 500 m (1640 ft.) results in a χ/Q value 4.7 times larger than the value for the 15-m (49-ft.) stack at 600 m (1969 ft.).

2.3.5 ROUTINE RELEASE SCENARIO

This subsection addresses long-term dispersion modeling approaches for assessing the χ/Qs to evaluate dose consequence of radiological releases resulting from normal operation.

The long-term dispersion modeling uses the USEPA COMPLY code (Version 1.7) to estimate the downwind routine annual doses for routine radioactive air emissions for both the RF and HCF. The wind data used for the routine dose evaluation is part of COMPLY's selectable wind rose data set identified as "HOBBS.NM."

The estimated dose values are calculated for selected radioisotopes and receptor locations assuming the receptor is at the location 24 hr. per day through the year. The COMPLY code estimates atmospheric concentrations using a Gaussian plume model. A 15 m-high (49 ft.-high) stack is assumed with no exit velocity and no building wake effects. A screening level of 4 is selected in the COMPLY input. Level 4 screening requires the most information and uses site specific data. χ/Q is not reported in the COMPLY output.

The estimated annual releases and doses from the RF and HCF during normal operation are described in Subsections 11.1.5.3 and 11.1.5.4, respectively.

Table 2.3-1
Local Meteorological Stations

Station	Type	County	Latitude (degrees)	Longitude (degrees)	Elevation (m, AMSL)	Period of Record
Hobbs	Cooperative	Lea	32.72630	-103.1313	1115.6	1912 – 2020
Hobbs 13 W	Cooperative	Lea	32.71250	-103.3538	1169.2	1996 – 2015
Lea County Regional Airport (KHOB; Hobbs FAA)	Automated station	Lea	32.69330	-103.2125	1114.0	1941 – 2022
Monument 1.2 W	Cooperative	Lea	32.62481	-103.2860	1097.9	2012 – 2022
Nadine 2 E	Cooperative	Lea	32.62360	-103.0842	1001.3	2009 – 2022
Ochoa	Cooperative	Lea	32.16640	-103.4249	1035.7	1942 – 2019
Pearl	Cooperative	Lea	32.65000	-103.3833	1158.2	1906 – 1996

Abbreviations: m = meters | AMSL = above mean sea level | FAA = Federal Aviation Administration

Table 2.3-2
(Sheet 1 of 2)
Climate Summary from Lea County Regional Airport (KHOB), NM (2017 – 2021)

	DBT (˚C)			Dew Point Temperature (˚C)	Wind Speed (m/s)	Liquid Equivalent Precipitation (cm)
Month	**Average Daily Maximum**	**Average Daily Minimum**	**Average Daily**	**Average Daily**	**Average Daily**	**Average Monthly**
January	13.9	-1.3	5.7	-5.9	4.6	0.51
February	16.8	-0.1	7.6	-5.6	4.8	0.04
March	21.7	5.3	13.0	-1.5	5.1	1.00
April	26.1	8.2	16.5	-0.3	5.4	1.26
May	30.8	13.8	22.3	5.0	5.3	0.65
June	34.7	18.5	26.6	10.7	4.8	2.53
July	34.4	20.2	27.3	13.4	4.1	0.85
August	34.0	19.9	26.8	14.0	3.9	2.61
September	30.1	15.8	22.5	12.1	3.9	1.55
October	24.8	9.1	16.2	4.4	4.5	1.21
November	19.5	3.4	10.7	-0.8	4.5	0.39
December	15.8	-0.1	7.0	-5.6	4.6	0.34

Abbreviations: DBT = dry bulb temperature | °C = degree Celsius | m/s = meters/second | cm = centimeters

Table 2.3-2
(Sheet 2 of 2)
Climate Summary from Lea County Regional Airport (KHOB), NM (2017 – 2021)

	Average Daily DBT (°C)		Average Daily Minimum DBT (°C)		Average Daily Maximum DBT (°C)		Average Monthly Precipitation (cm)	
Month	**1981 – 2010[a]**	**2017 – 2021**	**1981 – 2010[a]**	**2017 – 2021**	**1981 – 2010[a]**	**2017 – 2021**	**1981 – 2010[a]**	**2017 – 2021**
January	6.44	5.7	-1.17	-1.3	14.1	13.9	2.1	0.51
February	8.67	7.6	0.56	-0.1	16.7	16.8	1.8	0.04
March	12.4	13.0	3.72	5.3	21.1	21.7	1.8	1.00
April	17.3	16.5	8.33	8.2	26.3	26.1	2.7	1.26
May	22.1	22.3	13.3	13.8	30.9	30.8	6.0	0.65
June	26.2	26.6	17.7	18.5	34.7	34.7	4.5	2.53
July	27.2	27.3	19.5	20.2	34.8	34.4	6.9	0.85
August	26.4	26.8	19.2	19.9	33.8	34.0	5.3	2.61
September	22.8	22.5	15.3	15.8	30.2	30.1	6.9	1.55
October	17.6	16.2	9.67	9.1	25.4	24.8	3.5	1.21
November	11.1	10.7	3.17	3.4	19.0	19.5	2.1	0.39
December	6.33	7.0	-1.44	-0.1	14.1	15.8	1.9	0.34

Abbreviations: °C = degree Celsius | DBT = dry bulb temperature | cm = centimeters
a) NUREG-2239

Table 2.3-3
Severe Weather Events Reported in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2022

	Number of Events			
Type of Event	**Andrews County**	**Gaines County**	**Lea County**	**Description of Event [(a)]**
Flash Flood	43	66	82	A life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam).
Hail	190	222	457	Frozen precipitation in the form of balls or irregular lumps of ice. Although the minimum size of hail qualifying as “severe” is 1 in. (2.54 cm) in diameter, reports of hail 0.75 in. (1.88 cm) or larger in diameter is reported. Observed hail accumulations of smaller sizes, or instances where hail accumulates to a measurable depth that cause property and/or crop damage, are also reported. Injuries or fatalities that result from hail of any size are reported as well.
Heavy Rain	236	237	4	Unusually large amount of rain that does not cause a flash flood or flood event but causes damage.
High Wind	12	22	69	Sustained non-convective winds of 40 mph (18.0 m/s) or greater lasting for 1 hr. or longer, or gusts of 58 mph (25.7 m/s) or greater for any duration.
Thunderstorm Wind	206	247	225	Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 58 mph (25.7 m/s), or winds of any speed producing a fatality, injury, or damage.
Tornado	25	37	93	A violently rotating column of air, extending to or from a cumuliform cloud or underneath a cumuliform cloud, to the ground, and often (but not always) visible as a condensation funnel.

Abbreviations: in. = inch | cm = centimeters | mph = miles per hour | m/s = meters per second | hr. = hour
a) Event descriptions extracted from NWS, 2021

Table 2.3-4
Fujita Scale and Enhanced Fujita Scales to Determine Tornado Intensity

F scale	Fastest ¼-mi. (mph)	3-second gust (mph)	EF scale	3-second gust (mph)
0	40 – 72	45 – 78	0	65 – 85
1	73 – 112	79 – 117	1	86 – 110
2	113 – 157	118 – 161	2	111 – 135
3	158 – 207	162 – 209	3	136 – 165
4	208 – 260	210 – 261	4	166 – 200
5	261 – 318	262 – 317	5	over 200

Abbreviations: F = Fujita scale | mi. = mile | mph = miles per hour | EF = Enhanced Fujita scale

Table 2.3-5
Intensity of Tornadoes Reported in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2022

County	Tornado Intensity					
	F0/EF0	F1/EF1	F2/EF2	F3/EF3	F4/EF4	F5/EF5
Andrews	13	10	2	0	0	0
Gaines	26	6	4	1	0	0
Lea	64	20	8	1	0	0
Total	**103**	**36**	**14**	**2**	**0**	**0**

Abbreviations: F = Fujita scale | EF = Enhanced Fujita scale

Table 2.3-6
Summary of the Highest Intensity Tornadoes Observed within 50 Mi. (80 Km) of the EIPC from 1950 to 2021

State	County	Date	Tornado Intensity
New Mexico	Lea	5/17/1954	F3
Texas	Winkler	5/30/1955	F2
Texas	Yoakum	5/15/1957	F2
New Mexico	Lea	7/24/1960	F2
Texas	Terry	5/20/1961	F2
Texas	Gaines	6/18/1961	F2
Texas	Ector	7/21/1961	F2
Texas	Andrews	6/16/1962	F2
Texas	Gaines	4/19/1969	F3
Texas	Ector	6/3/1969	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/13/1971	F2
New Mexico	Lea	6/14/1972	F2
Texas	Ector	5/12/1973	F2
New Mexico	Eddy	4/30/1976	F2
Texas	Terry	6/3/1981	F2
Texas	Ector	10/15/1981	F2
Texas	Andrews	5/12/1982	F2
Texas	Gaines	5/12/1982	F2
New Mexico	Lea	5/27/1982	F2
New Mexico	Eddy	5/31/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Eddy	6/7/1992	F2
Texas	Gaines	4/10/1997	F2
Texas	Loving	4/30/1999	F2
New Mexico	Lea	3/23/2007	EF2
Texas	Ector	5/14/2010	EF3
Texas	Ector	3/18/2012	EF2
Texas	Gaines	11/16/2015	EF2
New Mexico	Eddy	3/12/2019	EF2
Texas	Ector	5/20/2019	EF3

Abbreviations: mi. = mile(s) | km = kilometer(s) | F = Fujita scale | EF = Enhanced Fujita scale

Table 2.3-7
Computed Lightning Strike Density at Roswell, NM, and Midland, TX

Station	Thunderstorm Days	Period of Record	Computed Number of Lightning Strikes per Square Mile
Midland	34.5	1948 – 2022	10.7
Roswell	29.2	1953 – 2022	9.1

Table 2.3-8
Summary of Observed Hail in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2022

Hail Diameter (in.)	Number of Events
≤ 1.0 in.	490
1 ≤ 2.0 in.	285
2 ≤ 3.0 in.	75
3 ≤ 4.0 in.	7
> 4 in.	8
Total	**865**

Abbreviations: in. = inch

Table 2.3-9
Maximum Daily Liquid Equivalent Precipitation and Snowfall from Local Meteorological Stations

Weather Observing Station	Maximum Daily Liquid Equivalent Precipitation (in.)	Maximum Daily Snowfall (in.)
Hobbs	7.5	11.0
Hobbs 13 W	4.5	4.0
Lea County Regional Airport (Hobbs FAA)[(a)]	3.63	9.0
Monument 1.2 W	3.73	8.0
Nadine 2 E	4.6	**15.0**
Ochoa	6.4	9.0
Pearl	**10.53**	**10.0**

Abbreviations: in. = inch | FAA = Federal Aviation Administration
a) Compiled using data available from WRCC (WRCC, 2022) for 1941 – 2016 and NCEI (NCEI, 2022b) for 2016 – 2021.
Note: Bold text denotes extremes.

Table 2.3-10
Average Number of Days with Heavy Fog at Midland, TX, and Roswell, NM

Month	Midland[(a)]	Roswell[(b)]
January	3.3	2.4
February	2.4	1.7
March	1.0	0.7
April	0.6	0.2
May	0.4	0.3
June	0.1	0.1
July	0.0	0.1
August	0.1	0.1
September	0.5	0.7
October	1.2	1.5
November	2.2	1.8
December	2.7	2.0
Annual	14.5	11.6

Sources: NCEI, 2022e; NCEI, 2022f
a) Midland, TX, heavy fog average based on 59 years of data.
b) Roswell, NM, heavy fog average based on 54 years of data.

Table 2.3-11
Design Dry Bulb and Wet Bulb Temperatures

Station	DBT (°F)		Dry Bulb/MCWBT (°F)		
	99.6%	99.0%	0.4%	1%	2%
Midland International Air and Space Port (1994 – 2019)	20.7	24.6	101.6 / 67.2	99.2 / 67.4	97.0 / 67.5

Source: ASHRAE, 2021.
Abbreviations: DBT = dry bulb temperature | MCWBT = mean coincident wet bulb temperature | °F = degree Fahrenheit

Table 2.3-12
Computed 100-Year Return-Interval Extreme Temperatures

	Mean and Standard Deviation of Extreme Annual Temperatures (°F) at Midland International Air and Space Port, TX (1994 – 2019)[a]				Computed 100-Year Return Interval Extreme Temperatures (°F)	
	Mean (M)		Standard Deviation (s)			
	Min.	Max.	Min.	Max.	Min.	Max
Dry Bulb	14.2	106.2	3.5	3.4	3.2	116.9
Non-Coincident WB	12.2	74.5	3.2	1.3	2.2	78.6

Abbreviations: °F = degree Fahrenheit | min. = minimum | max. = maximum | WB = wet bulb
a) from ASHRAE, 2021.

Table 2.3-13
Daily Maximum and Minimum Dry Bulb Temperatures from Local Meteorological Stations

	DBT (°F)	
Observing Station	**Maximum**	**Minimum**
Hobbs	114	-7
Hobbs 13 W	113	1
Lea County Regional Airport (Hobbs FAA)[a]	108	**-11**
Monument 1.2 W[b]	--	--
Nadine 2 E[b]	--	--
Ochoa	**118**	-6
Pearl	109	**-11**

Abbreviations: DBT = dry bulb temperature | °F = degree Fahrenheit | FAA = Federal Aviation Administration
a) Compiled using data available from WRCC (WRCC, 2022) for 1941 – 2016 and NCEI (NCEI, 2022b) for 2016 – 2021.
b) Temperature not measured at this station.
Note: Bold text denotes extremes.

Table 2.3-14
Seasonal and Annual Average Mixing Heights at Midland, TX

	Morning		Afternoon	
Season	**(m)**	**(ft.)**	**(m)**	**(ft.)**
Winter	290	951	1276	41908
Spring	429	1407	2449	8035
Summer	606	1988	2744	9003
Autumn	419	1375	1887	6191
Annual	**436**	**1430**	**2089**	**6854**

Source: Holzworth, 1972
Abbreviations: m = meters | ft. = feet

Table 2.3-15
National Ambient Air Quality Standards

Pollutant	Primary/ Secondary Standard	Averaging Period	Level ($\mu g/m^3$)	Level (ppm)
CO[a]	Primary	1 hr.	--	35
CO[a]	Primary	8 hr.	--	9
Pb[b]	Primary and secondary	Rolling 3-month average	0.15	--
NO_2[c]	Primary	1 hr.	--	0.1
NO_2	Primary and secondary	Annual	--	0.053
O^3[d]	Primary and secondary	8 hr.	--	0.070
$PM_{2.5}$[e]	Primary and secondary	24 hr.	35	--
$PM_{2.5}$	Primary	Annual	12.0	--
$PM_{2.5}$	Secondary	Annual	15.0	--
PM_{10}[f]	Primary and secondary	24 hr.	150	--
SO_2[g]	Primary	1 hr.	--	0.075
SO_2[a]	Secondary	3 hr.	--	0.5

Abbreviations: $\mu g/m^3$ = micrograms per cubic meter | ppm = parts per million | CO = carbon monoxide | Pb = lead | hr. = hour | NO_2 = nitrogen dioxide | O^3 = ozone | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | SO_2 = sulfur dioxide

a) Not to be exceeded more than once per year.

b) In areas designated nonattainment for the lead standards prior to promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have been submitted and approved, the previous standards (1.5 $\mu g/m^3$ calendar quarter average) also remain in effect.

c) 98th percentile of 1-hr. daily maximum concentrations averaged over 3 years.

d) Annual fourth-highest daily maximum 8-hr. concentration averaged over 3 years.

e) 98th percentile averaged over 3 years.

f) Not to be exceeded more than once per year on average over 3 years.

g) 99th percentile of 1-hr. daily maximum concentrations averaged over 3 years.

Table 2.3-16
New Mexico Ambient Air Quality Standards

Pollutant	Averaging Period	Level (ppm)	Form	Note
CO	1 hr.	13.1	Not to be exceeded	--
CO	8 hr.	8.7	Not to be exceeded	--
NO_2	24 hr.	0.10	Not to be exceeded	--
NO_2	Annual	0.05	Not to be exceeded	--
SO_2	3 hr.	0.50	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
SO_2	24 hr.	0.10	Not to be exceeded	--
SO_2	24 hr.	0.14	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
SO_2	Annual	0.02	Not to be exceeded	--
SO_2	Annual	0.03	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
H_2S	0.5 hr.	0.100	Not to be exceeded	For the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	0.5 hr.	0.030	Not to be exceeded	Within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	0.5 hr.	0.03	Not to be exceeded	Within 5 mi. of the corporate limits of municipalities having a population of greater than 20,000 and within the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	1 hr.	0.010	Not to be exceeded	For the state except the Pecos-Permian Basin Intrastate Air Quality Control Region
TRS	0.5 hr.	0.003	Not to be exceeded	For the state except the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.010	Not to be exceeded	For the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.003	Not to be exceeded	For within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.003	Not to be exceeded	For within 5 mi. of the corporate limits of municipalities having a population of greater than 20,000 and within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S

Abbreviations: ppm = parts per million | CO = carbon monoxide | hr. = hour(s) | NO_2 = nitrogen dioxide | SO_2 = sulfur dioxide | mi. = miles | H_2S = hydrogen sulfide | TRS = total reduced sulfur

Table 2.3-17
Annual Air Pollutant Emissions for Lea County, NM, and Andrews and Gaines Counties, TX

County	Pollutant (metric tons per year)[a]						
	CO	**HAPs**	**NO_2**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOCs**
Lea, NM	27,698	10,959	15,626	2029	13,104	5037	88,614
Andrews, TX	11,925	4586	8331	282	904	1785	49,567
Gaines, TX	8132	3358	4162	1182	5716	532	31,254
Total	**47,755**	**18,903**	**28,119**	**3493**	**19,724**	**7354**	**169,435**

Abbreviations: CO = carbon monoxide | HAPs = hazardous air pollutants | NO_2 = nitrogen dioxide | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | SO_2 = sulfur dioxide | VOCs = volatile organic compounds
a) Emissions from NUREG-2239, Table 3.7-4.

Table 2.3-18
Nearest Federal Class I Areas to the EIPC

Class I Area [(a)]	Distance from the EIPC (km)	Direction from the EIPC
Carlsbad Caverns National Park, NM	142	west
Guadalupe Mountains National Park, TX	180	west-southwest
Salt Creek Wilderness Area, NM	182	northwest

Abbreviations: EIPC = Eden Isotope Production Complex | km = kilometers
a) Distances extracted from USEPA (USEPA, 2022d) and NPS (NPS, 2022a)

Table 2.3-19
(Sheet 1 of 2)
FAA Specifications for Automated Weather Observing Stations[a]

Parameter	Range	Accuracy	Resolution	Other
DBT	-30° – +130°F (-35° – +55°C)	1°F RMSE over entire range with max. error of 2°F	≤ 1°F	time constant ≤ 2 min.
Relative humidity	5 – 100%	≤ 5%	≤ 1°%	time constant < 2 min.
Wind speed	2 – 85 knots	a) ± 2 knots up to 40 knots b) RMSE ± 5% above 40 knots	1 knot	a) distance constant < 10 m b) 2-knot threshold
Wind direction	1°– 360° azimuth	± 5% RMSE	1°	a) time constant < 2 seconds b) 2-knot threshold
Pressure	17.58 – 31.53 in. Hg	a) ± 0.02 in. Hg RMSE b) maximum error 0.02 in. Hg	0.001 in. Hg	drift ± 0.02 in. RMSE Hg for period not less than 6 months
Visibility	< 1/4 – 10 mi.	a) 1/4 – 1-1/4 mi.: ± 1/4 mi. b) 1-1/2 – 1-3/4 mi.: + 1/4, -1/2 mi. c) 2 – 2-1/2 mi.: ± 1/2 mi. d) 3 – 3-1/2 mi.: +1/2, -1 mi. e) ≥ 4 mi.: ± 1 mi.	< 1/4, 1/4, 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 4, 5, 7, 10, and > 10 mi.	time constant ≤ 3 min.
Precipitation	0.01 – 5 in/hr	0.002 in/hr RMSE or 4%, whichever is greater	in.	
Cloud height	0 to ≥ 12,500 ft.	100 ft. or 5%, whichever is greater	a) 0 – 5500 ft.: 50 ft. b) 5501 – 10,000 ft.: 250 ft. c) > 10,000 ft.: 500 ft.	a) sampling rate at least once every 30 seconds b) at least three cloud layers when visibility ≥1/4 mi.

Table 2.3-19
(Sheet 2 of 2)
FAA Specifications for Automated Weather Observing Stations[a]

Parameter	Range	Accuracy	Resolution	Other
Time	0000 – 2359 UTC	within 15 seconds each month	1 second	

Abbreviations: DBT = dry bulb temperature | FAA = Federal Aviation Administration | °F = degree Fahrenheit | °C = degree Celsius | RMSE = root mean square error | min. = minute(s) | m = meters | in. Hg = inches of mercury | mi = miles | in/hr = inches per hour | in. = inches | ft. = feet | UTC = Coordinated Universal Time
a) from FAA, 2017.

Table 2.3-20
Tadmor-Gur Constants for σ_y and σ_z Equations

Stability Class	a	b	c	d
A	0.3658	0.9031	0.00025	2.1250
B	0.2751	0.9031	0.0019	1.6021
C	0.2089	0.9031	0.20	0.8543
D	0.1474	0.9031	0.30	0.6532
E	0.1046	0.9031	0.40	0.6021
F	0.0722	0.9031	0.20	0.6020

2.4 HYDROLOGY

2.4.1 HYDROLOGICAL DESCRIPTION

2.4.1.1 Surface Water

The proposed project site is within the Hydrologic Unit Code (HUC) 12 130700070206 sub-watershed, which is part of the Lower Pecos subregion (Figure 2.4-1). The nearest river to the project site is the Pecos River, located about 75 mi. (121 km) to the west of Eunice, NM, near Carlsbad, NM, per a biological desktop review prepared for the site. Surface water in the vicinity of the project site and in surrounding Lea County is limited to unnamed intermittent streams and small playa lakes that result from heavy monsoon rainfall events (LCWUA, 2000).

Within the project site boundary and within the off-site utility corridor, no permanent surface water features are present. Stormwater drainage from the project site generally flows to the southwest, as identified in the Phase I Environmental Site Assessment (prepared by NV5 in 2020).

The NRC prepared EISs in support of the URENCO license application (NUREG-1790) and the CISF license application (NUREG-2239). Due to the proximity to the EIPC, portions of the EISs are used herein with the corresponding reference noted where appropriate.

The proposed project site is located within the Landreth-Monument Draw watershed (Figure 2.4-1). This watershed covers a total of 4,057,150 ac. (16,419 square kilometers [km^2]) across Texas and New Mexico (NRCS, 2002). The main surface water feature within a 5-mi. (8-km) radius of the project site is Monument Draw, an intermittent stream located to the southwest of the project site (Figure 2.4-2). Additionally, draws, drainage areas, and surface depressions in the vicinity are ephemeral and may seasonally contain water for short durations following precipitation events, though they dry out quickly due to evapotranspiration and infiltration. Surface water features in the vicinity generally occur in response to precipitation events, as described in NUREG-2239. Based on a review of the National Hydrography Dataset (NHD) and National Wetland Inventory (NWI) for potential Waters of the U.S., no wetlands are located within the project site or within the off-site utility corridor. Approximately 31.2 ac. (0.13 km^2) of NWI emergent wetlands and 95.7 ac. (0.39 km^2) of NWI scrub/shrub wetlands are mapped in the vicinity of the project site (Figure 2.4-2).

No large-scale surface water bodies or through-flowing drainage systems occur in the Pecos River Basin (LCWUA, 2000).

No permanent surface water bodies (streams, lakes, or ponds) or drainage features occur within the project site or within the off-site utility corridor. As described in NUREG-1790, Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, NM, local surface water features in the vicinity of the project site include Monument Draw, Baker Spring, and several ponds on nearby industrial properties. A total of 60.9 ac. (0.25 km^2) of open water is present within a 5-mi. (8-km) radius of the project site, consisting primarily of manmade ponds and impoundments. There are no operational U.S. Geological Survey (USGS) stream gages in Lea County.

Only one named drainage feature, Monument Draw, is located near the project site. It consists of approximately 6.6 mi. (10.6 km) of noncontinuous streambed in the project vicinity (Figure 2.4-2). Although Monument Draw is typically dry, a maximum historical flow of 1280 cubic feet

per second (cfs)(36.2 cubic meters per second [m^3/s]) occurred on June 10, 1972, per NUREG-1790. However, there is no direct outfall to Monument Draw from the project site. Stormwater drainage from the off-site utility corridor may result in small-scale outfall to Monument Draw. Surface water is present intermittently in Baker Spring, which is located northeast of the project site (Figure 2.4-2). Baker Spring surface water is impounded and localized when present, and surface water is attributed to seepage or precipitation and runoff, per NUREG-1790.

Other surface water features in the vicinity of the project site are limited to intermittent streams and small ephemeral playa lakes that result from heavy rainfall each year during May through October, when 80 percent of annual rainfall occurs (indicated as open water on Figure 2.4-2). Water for livestock is the primary use of these intermittent surface water sources (NMISC, 2016).

2.4.1.2 Groundwater

Groundwater resources in the vicinity of the site include the Pecos River Basin Alluvial Aquifer, the High Plains Aquifer (Ogallala Formation), the Santa Rosa Aquifer (Dockum Group Formation), and the Rustler Formation. Details of each of these groundwater sources are presented in Table 2.4-1. The northern edge of the Pecos River Basin Alluvial Aquifer, which consists of alluvial deposits from the Pecos River Basin, is located near the project site. This aquifer is unconfined and, in some areas, not continuous. This aquifer consists of saturated alluvial and aeolian deposits along stream beds (NMISC, 2016). The Rustler Formation underlies all of Lea County (including the project site) and produces brackish to saline water (NMISC, 2016). Most of this formation is composed of evaporite beds, which have a low permeability and manifest water-quality limitations for potable or agricultural uses. A hydrostratigraphic cross section in Figure 2.4-3 illustrates the relationship between the Dockum Group and High Plains Aquifer in this region. Additionally, localized shallow groundwater can occur in the vicinity. Groundwater volume in these areas is limited, and recharge is attributed to infiltration from substantial surface depressions that collect surface water runoff, per NUREG-1790.

As illustrated in Figure 2.4-4, the project site is located near the southern edge of the High Plains Aquifer (also known as the Ogallala Aquifer), which is part of the Ogallala Formation in New Mexico. The High Plains Aquifer contains approximately 3.3 billion acre-feet (ac-ft) (4 trillion cubic meters [m^3]) of water and is the largest groundwater system in North America. The aquifer is located primarily under the High Plains from west of the Mississippi River to the Rocky Mountains. The aquifer system underlies 174,000 square miles (mi^2) (450,000 km^2) of land and extends under portions of at least eight states: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming, per NUREG-1790. An estimated 200 million ac-ft (247 billion m^3) of saturated material exists in the High Plains Aquifer in New Mexico, with an estimated 3590 mi^2 (9298 km^2) of High Plains Aquifer area that contains little or no saturated thickness (McGuire et al., 2012).

In Lea County, only 0.25 in. to 0.5 in. (0.64 cm to 1.27 cm) of precipitation each year infiltrates and recharges the High Plains Aquifer (Musharrafieh and Chudnoff, 1999). Estimates of recharge to the High Plains Aquifer in Lea County, NM, range between 37,500 ac-ft and 75,000 ac-ft (46.5 million to 92.5 million m^3) per year (LCWUA, 2000). Historically, the High Plains Aquifer flowed to the southeast with a gradient of 15.0 feet per mile (ft/mi) to 15.8 ft/mi (2.8 meters per kilometer [m/km] to 3.0 m/km). Intensive pumping and water removal from the aquifer in New Mexico and Texas have resulted in overall declines in water level and a shift in groundwater flow. A more recent evaluation indicates flow to the southeast at a gradient of

approximately 13 ft/mi to 13.7 ft/mi (2.5 m/km to 2.6 m/km) (LCWUA, 2000; NMISC, 2016). Specific yield in Lea County, or the volume of water that can be drained by gravity from the saturated sediments per unit drop in the water table, ranges from 10 percent to 28 percent (Musharrafieh and Chudnoff, 1999; LCWUA, 2000).

Saturated thickness of aquifers present in Lea County, NM, can be found in Table 2.4-1. In New Mexico, the average water level in the High Plains Aquifer decreased by 16.5 ft. (5.0 m) between 1950 (predevelopment) and 2015 (McGuire, 2017). In Lea County, High Plains Aquifer groundwater level declines of 50 ft. to 100 ft. (15 m to 30 m) have been reported over this same time period as a result of intensive groundwater withdrawals (McGuire, 2014; NMISC, 2016). The average rate of decline of High Plains Aquifer groundwater levels in Lea County is 0.59 ft. (0.18 m) per year (NMISC, 2016). Estimates of aquifer drawdown along the Texas border indicate that water levels have declined in excess of 60 ft. (18.3 m) and, in some localized areas, more than 80 ft. (24.4 m) since 1940, largely as a result of pumping in Texas (LCWUA, 2000). Water table levels reported in 2007 for the High Plains Aquifer in Lea County are illustrated in Figure 2.4-5.

In the Santa Rosa Aquifer, declines in water level of up to 50 ft. (15 m) occurred from 1968 to 1998 in some areas within the aquifer, but increases in other areas of 10 ft. to 30 ft. (3 m to 9 m) were also observed over this time period (LCWUA, 2000).

In the Pecos River Basin Alluvial Aquifer, saturated thickness is substantial in some places but thin at most locations. Declines in water level have occurred in some areas of the aquifer as a result of groundwater pumping and evapotranspiration. Recharging of this aquifer is primarily linked to infiltration of surface water from surrounding uplands or ephemeral stream beds (LCWUA, 2000).

Nearby USGS monitoring wells, illustrated in Figure 2.4-6, are used to track groundwater levels in aquifers. The depth to water at the Pecos River Basin Alluvial Aquifer Well, approximately 6.2 mi. (10.0 km) from the project site, from 1965 to 2022 ranged from 60 ft. to 65 ft. (18 m to 20 m) (USGS, 2022a). The depth to water in the monitoring well at the Santa Rosa Sandstone Well (Santa Rosa Aquifer), located 2.7 mi. (4.3 km) from the project site, from 1953 to 2021 ranged from 129 ft. to 150 ft. (39 m to 46 m) (USGS, 2021). Finally, the depth to water in the Ogallala Formation Well (High Plains Aquifer), located 10.0 mi. (16.1 km) from the project site, from 1953 to 2022 ranged from 204 ft. to 206 ft. (62 m to 63 m) (USGS, 2022b).

Based on data from private wells within 1 mi. (1.6 km) of the project site collected in the Phase I Environmental Site Assessment (prepared by NV5 in 2020), the depth to groundwater in the project vicinity ranges from 16 ft. to 241 ft. (4.8 m to 73.5 m). Data from these wells indicate that groundwater at the project site generally flows to the northwest. Localized, shallow groundwater exists in the vicinity of the project site, near the Wallach Concrete, Inc. and Sundance Services, Inc. properties to the northeast; however, this localized subsurface saturation is limited. This saturated zone is characterized by discontinuity and low permeability, suggesting that this groundwater is a perched water condition and not an aquifer, per NUREG-1790.

Groundwater resources in Lea County, NM, are divided into five major distinct underground water basins (UWBs). These basins are illustrated in Figure 2.4-7 and include the following UWBs:

- Lea County UWB (2671.0 mi^2 [6917.9 km^2]).

- Roswell UWB (55.3 mi^2 [143.2 km^2]).
- Capitan UWB (1143.2 mi^2 [2960.9 km^2]).
- Carlsbad UWB (509.4 mi^2 [1319.3 km^2]).
- Jal UWB (approx. 14.6 mi^2 [37.8 km^2]).

The Lea County UWB is the municipal water source for Eunice, NM (NMISC, 2016). The Lea County UWB extends from east to west across Lea County and is bounded to the south by Mescalero Ridge (see Figure 2.5-2). The primary aquifer that supplies the Lea County UWB is the High Plains Aquifer; however, in some locations the aquifer is not present or the saturated thickness is small (NMISC, 2016). The average estimated annual recharge to the Lea County UWB is between 29,000 ac-ft and 58,000 ac-ft (35.8 million m^3 to 71.5 million m^3). Downward percolation from the High Plains (Ogallala) Aquifer is limited by Cretaceous Period and Triassic Period rocks underlying the Ogallala Formation.

The project site is within the limits of the Capitan UWB. The Capitan UWB occurs within dolomite and limestone strata that were deposited as an ancient reef formation (LCWUA, 2000). Within the Capitan UWB, isolated areas of saturated Ogallala Formation resources are approximately 50 ft. (15 m) thick; however, these areas are not formally included in the High Plains Aquifer.

In Texas, groundwater resources are divided into Groundwater Conservation Districts (GCDs). However, Andrews County, TX, does not have a formally defined GCD, and, therefore, there are no GCDs in the vicinity of the project site.

2.4.2 FLOODS

As stated in Subsection 2.4.1, the closest water conveyance is Monument Draw, a typically dry, intermittent stream located approximately 2.5 mi. (4 km) west of the site (URENCO, 2005). The maximum historical flow for Monument Draw is 36.2 m^3/s (1280 cfs) measured on June 10, 1972. All other historical maximum measurements are below 2.0 m^3/s (70 cfs) (USGS, 2003). The Federal Emergency Management Agency (FEMA) does not publish maps of special flood hazard areas for this location. Therefore, no special design considerations, other than local intense precipitation, are needed for flooding at the site.

The short duration-small area local intense probable maximum precipitation (PMP) was obtained from U.S. NOAA Hydrometeorological Report No. 52 (NOAA, 1982). The local intense PMP is 17.3 in. (43.9 cm) in 1 hr. over 1 mi^2 (2.6 km^2).

The proposed project site is located south of NM-176 with the general topography of the area sloped from north to south toward the site. Because of this, areas to the north and east drain toward the site. As shown on Figure 2.4-8, drainage ditches are strategically located at the north and east sides of the site that act as intercepting flood carriers. These ditches capture the off-site flow generated by the PMP and redirect the runoff away from the site. Calculations demonstrate that the diversion ditches provide adequate drainage to preclude overtopping in this event. Protection against flooding of the RF and HCF is provided by establishing the facility floor level 0.5 ft. (0.15 m) above the high point of finished grade elevation and all roads at least 1.5 ft. (0.45 m) below this.

2.4.3 PROBABLE MAXIMUM FLOOD ON STREAMS AND RIVERS

There are no bodies of water in the immediate vicinity of the site. Therefore, flooding from streams and rivers is not a design basis event for the site.

2.4.4 POTENTIAL DAM FAILURES

The project site does not include any freshwater lakes or ponds. No reservoirs or impoundments are present within the project site or in the vicinity. Therefore, the project site is not subject to this flooding scenario.

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

The EIPC site is not adjacent to a seacoast subject to hurricanes. Consequently, surge due to probable maximum hurricane (PMH) is not a credible threat to the facility. Similarly, PMH wind and maximum windstorm-induced (non-hurricane) wave action is also not applicable to the site.

The EIPC site is not adjacent to any large body of water. Consequently, meteorologically induced seiches in inland lakes, coastal harbors, and embayments are not a credible threat to the facility.

2.4.6 PROBABLE MAXIMUM TSUNAMI HAZARDS

The EIPC site is not adjacent to a seacoast or any large body of water that is subject to tsunami. Consequently, tsunami-induced flooding is not a credible threat to the facility.

2.4.7 ICE EFFECTS

There are no streams or rivers in the immediate vicinity of the site that can be subject to ice effects. Therefore, flooding or lack of water in front of the intake from this scenario is not a design basis event for the site.

2.4.8 COOLING WATER CANALS AND RESERVOIRS

Canals and reservoirs used to transport and impound water supplied to the safety-related structures, systems, and components are not included in the design for the EIPC facility.

2.4.9 CHANNEL DIVERSIONS

No channel diversions are included in the design of the EIPC facility.

2.4.10 GROUNDWATER CONTAMINANT CONSIDERATIONS

Indirect impacts to groundwater quality can occur during construction, operation, and decommissioning of the EIPC. These impacts are related to spills from vehicles, equipment, or storage areas that penetrate hard surfaces or are accidentally released to pervious surfaces and migrate to groundwater prior to detection and remediation. Best management practices (BMPs) to mitigate incidental spills include abiding by the spill prevention, control, and countermeasure plan (SPCC Plan). Ongoing and foreseeable future actions within the geographic area of impact (GAI) include operation of nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities. These facilities have the potential to cause groundwater contamination, particularly oil

and gas mining operations, through improperly plugged or cased wells and through incidental spills from equipment.

As described in Section 9a.7, water used by the EIPC facility is obtained through the Eunice municipal water supply and sanitary wastewater is discharged directly to the Eunice wastewater system. Because construction, operations, and decommissioning activities are not supported by the direct extraction of groundwater on-site, direct impacts to groundwater quality are not anticipated.

An underground pipeline system is used to transport the liquid effluent control system (LECS) wastewater from the Eden Medical Isotope Facility (EMIF) decontamination stations, laboratory spaces, and floor drains where radioactive and/or hazardous chemicals may be present. These pipelines are equipped with leak-detection devices to immediately identify spills. Oil storage associated with facility operations includes a double-walled diesel fuel storage tank that provides 8000 gal. (30,300 L) of fuel storage. The storage tank(s) may be located either underground or aboveground. Fuel storage associated with construction and decommissioning is within secondary containment, minimizing the potential of releases migrating through the subsurface and impacting groundwater. Oil storage on-site requires an SPCC Plan in accordance with 40 CFR Part 112. The SPCC Plan details the requirements for oil spill prevention, preparedness, and response regarding oil discharges.

The HCF includes a basement for the long-term staging of full waste drums within a shielded canyon (the waste storage canyon). The waste storage canyon contains waste that has been neutralized and then solidified with other waste generated in the hot cells. This waste is stored in a solidified form, decreasing the likelihood of leakage. Because waste is neutralized and solidified, it is unlikely to leak into groundwater systems.

Measured groundwater levels are below the deepest excavation during construction and decommissioning and below the base of the lowest basement, which prevents any direct impacts to groundwater. Construction of the EIPC includes excavations for building construction, basements, and the belowground RF. Construction excavation is minimal, less than 2 m (6.5 ft.) deep in most areas, including buildings, adjacent pads, and utility trenches. Deeper excavations are required for construction of basements and the RF. The deepest excavation is for the reactor portion of the EMIF, which is 35 ft. (10.7 m) below grade. Based on data from private wells within 1 mi. (1.6 km) of the project site, the depth to groundwater in the project vicinity ranges from 16 ft. to 241 ft. (4.9 m to 73.5 m). The water well, with a reported depth to water at 16 ft. (4.9 m), is related to a localized, discontinuous, shallow perched saturation zone not associated with an aquifer, per NUREG-1790. This zone exists in the vicinity of the project site within properties to the northeast, near the Wallach Concrete, Inc. and Sundance Services, Inc. facilities. Of the three closest water wells that report depth to water, all within 1 mi. (1.6 km) of the site, depth to water ranges from 16 ft. to 241 ft. (11.9 m to 73.5 m). Excavations required for the EIPC facility are not located near these areas of saturation; they occur near the center of the EIPC site. Consequently, there is no direct impact to groundwater flow as a result of deep excavations.

Table 2.4-1
Primary Groundwater Aquifers in Central Lea County in the Project Site Vicinity

Primary Aquifer[a]	Associated Geologic Formation	Depth to Water in Feet (ft.)	Slope Direction	Potentiometric Surface Elevation (AMSL)	Saturated Thickness	Water Use
Pecos River Basin Alluvial Aquifer	Quaternary Alluvium	50 ft. – 100 ft.	Not reported	Not reported	> 500 ft.	Limited domestic and livestock uses
High Plains Aquifer	Ogallala Formation	20 ft. – 250 ft.	Southeast at a gradient of 13 – 13.7 ft/mi	<3750 ft.[b]	Declining as a result of pumping drawdown; <200 ft.[c]	Domestic, agriculture, and industrial use; primary water source for all groundwater in Lea County, including public water supply
Santa Rosa Aquifer	Dockum Group	120 ft. – 700 ft.	Southwest	2820 ft. – 3400 ft.	Average: 200 ft. – 250 ft.; Maximum: 2400 ft.	Domestic and livestock uses in southern Lea County
Rustler Formation	Permian	240 ft. – 355 ft.	Southwest	2835 ft. – 2765 ft.	90 ft. – 450 ft.[d]	Limited primarily to livestock watering, brackish saline water

Source: LCWUA, 2000; McGuire et al., 2012, Rinehart and Mamer, 2017.
Abbreviations: ft. = feet | AMSL = above mean sea level | ft/mi = feet per mile

a) Aquifers are presented in order of relative depth.
b) In the Ogallala Aquifer between Hobbs and Eunice, NM; 2010 model estimates.
c) Saturated thickness within Lea County, NM.
d) Formation thickness.

2.5 GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING

This section provides a description of the regional geology, site geology, seismicity, and earthquake potential at the proposed project site in Lea County, NM. Non-seismic geological hazards and earthquake-related hazards are identified. The NRC prepared an EIS in support of the CISF license application (NUREG-2239). Due to the proximity of the CISF to the EIPC, portions of the EIS are used herein with the corresponding reference noted where appropriate.

2.5.1 REGIONAL GEOLOGY

2.5.1.1 Regional Physiography

The proposed EIPC project site is located within southern Lea County, in the southeastern corner of New Mexico. This region is in the southern portion of the Great Plains physiographic province, which contains the Pecos Valley section and the High Plains section (Figure 2.5-1). Figure 2.5-2 is a physiographic map of southern Lea County showing geographic subdivisions and major geographic features. The project site is located in the Southern High Plains section, in close proximity to the boundary line between the High Plain section and the Pecos Valley section. The Southern High Plains section is locally referred to as the Llano Estacado (Figure 2.5-3). As shown on Figure 2.5-3, the Llano Estacado is located to the north and east of the project site. The Llano Estacado is a high isolated pediment surface mesa that covers much of the Texas Panhandle and the eastern third of southeastern New Mexico. The Llano Estacado plateau occupies approximately 37,000 mi^2 (22 million ac.) (96,000 km^2 [9 million ha]). It is believed that the name refers to the palisade-like escarpment that surrounds the plain (Nicholson and Clebsch, 1961). Mescalero Ridge marks the edge of the Llano Estacado part of the High Plains section on the north. In southern Lea County, Mescalero Ridge is an irregular erosional topographic feature with a relief of approximately 30 ft. to 50 ft. (9.1 m to 15.2 m) compared with a nearly vertical cliff and relief of approximately 150 ft. (45.7 m) in northwestern Lea County (IIFP, 2009).

The Llano slopes gently to the southeast by 8 ft. to 10 ft. (2.4 m to 3.1 m) per mile. Approximately 34,000 shallow depressions, called playas, provide the only changes in elevation in the plateau. The Llano Estacado is the largest isolated non-mountainous geological area in North America and home to many endemic plants and animals. South of the Portales Valley, the caliche caprock of the Ogallala Formation is generally near the surface; elsewhere, it is buried by sand and clay deposits. Surface drainage on the Southern High Plains (Llano Estacado) is poor, with larger regional drainages evident along the northwest to southeast lineaments (IIFP, 2009).

The Llano Estacado is bounded on the south by the Eunice Plain. The term Eunice Plain is used in Nicholson and Clebsch to refer the eastern part of the region (Nicholson and Clebsch, 1961). The Eunice Plain is underlain by a hard caliche surface and is almost entirely covered by reddish-brown dune sand. In some places the underlying surface consists of alluvial sediments – most commonly calcareous silt in buried valleys or Quaternary lake basins. The sand cover is 2 to 5 ft. (0.6 m to 1.5 m) thick over most of the area, but locally is up to 20 or 30 ft. (6.1 m or 9.1 m) thick, especially in the drift area (Nicholson and Clebsch, 1961).

The regional slope is to the southeast, and wherever drainage patterns have developed, they are consequent to the slope. Monument Draw, located immediately west of the project site, is the only major drainage feature within southern Lea County. Monument Draw traverses the east side of Eunice Plain from north to south. The north to south drainage course of Monument Draw

is almost perpendicular to the regional topography and drainage and conforms to the general trend only in its uppermost reaches. Farther east, in Texas, the regional slope is also east and southeast. In some places along its east side, the draw has some well-developed tributary drainage areas several miles long (Nicholson and Clebsch, 1961).

East of Monument Draw, the Eunice Plain rises toward a north-trending topographic high, known locally as Rattlesnake Ridge (Figure 2.5-2). Throughout most of its length, the crest of this ridge closely parallels the state line. Rattlesnake Ridge restricts Monument Draw to its north-south trend and is regarded as the drainage divide between the Pecos River Basin and the Colorado River Basin in Texas (Nicholson and Clebsch, 1961).

All stream courses in the project vicinity are ephemeral, and only one, Monument Draw, is located near the project site (Figure 2.5-2). Monument Draw traverses just west of the project site from north to south and extends into Texas (Nicholson and Clebsch, 1961).

2.5.1.2 Geologic Structure

The Permian Basin, a large subsurface structural feature, underlies a large part of western Texas and southeastern New Mexico. Figure 2.5-4 shows the major structural elements of the Permian Basin. Among them, the Delaware Basin and the Central Basin Platform are the major structural features of southern Lea County.

Figure 2.5-4 shows that the project site is located on the Central Basin Platform. The Central Basin Platform is composed of carbonate reef deposits and shallow marine clastic deposits. The Central Basin Platform extends northwest to southeast from southeastern New Mexico to eastern Pecos County, TX, and is a tectonically uplifted basement block capped by a carbonate platform. It is surrounded on three sides by regional structural depressions known as the Delaware Basin to the southwest, the Midland Basin to the northeast, and the Val Verde Basin to the south. The large structural features of the Permian Basin are reflected only indirectly in the Mesozoic and Cenozoic rocks, as there has been virtually no tectonic movement within the basin since the close of Permian time (Nicholson and Clebsch, 1961).

Red-bed erosion surface is another structural feature over southern Lea County. It is a buried erosion surface which underlies the rocks of Tertiary and Quaternary age. This surface is highly irregular but has only moderate relief. The erosion surface truncates the southeastward dipping formations; thus, in the western part of the area, the surface is cut into the Santa Rosa sandstone, and farther to the east it is cut into the Chinle Formation.

Another hydrologically important feature of the red-bed surface is the Red Bed Ridge. The Red Bed Ridge denotes the position of a drainage divide that has separated two major fluvial systems throughout the late Cenozoic Era. The area was uplifted at the start of the Laramide Orogeny when the Cretaceous seas retreated. From the late Paleocene to near the end of the Pliocene, the area was subjected to erosion, removing most of the Cretaceous deposits. The relatively resistant limestones over the partially silicified (i.e., silica-rich) Cretaceous Antlers Formation on the crest of the ridge may have effectively capped the Red Bed Ridge, maintaining the ridge as a mesa or inter-drainage high. The axis of the Red Bed Ridge runs long with a local topographic high between Monument Draw in Texas, which drains to the Colorado River, and Monument Draw in New Mexico, which drains to the Pecos River, per NUREG-2239.

2.5.1.3 Geologic History

Regions of western Texas and southeastern New Mexico experienced mild structural deformation that produced broad regional arches and shallow depressions during the Cambrian Period to late Mississippian Period. During the Mississippian and Pennsylvanian Periods, the Central Basin Platform uplifted, and the Delaware, Midland, and Val Verde Basins began to subside, forming separate basins. Also, Late Mississippian Period tectonic events uplifted and folded the Central Basin Platform. This uplift was followed by more intense late Pennsylvanian Period and early Permian Period deformation that compressed and faulted the area. The Late Paleozoic Era deformation was followed by a long period of gradual subsidence and erosion that stripped the Central Basin Platform and other structures to near base-level, forming the Permian Basin. Accumulating along the edges and flanks of the regional structures were layers of arkose, sand, chert pebble conglomerate, and shale deposits as the expanding sea gradually rose over the broad eroded surfaces and truncated edges of previously deposited sedimentary strata, per NUREG-2239.

Throughout the remainder of the Permian Period, the Permian Basin slowly filled with several thousand feet of evaporites, carbonates, and shales. During the Triassic Period, the area was once again slowly uplifted and eroded, eventually forming a large landlocked basin where deposits of the Dockum Group accumulated in alluvial floodplains and as deltaic (i.e., delta) and lacustrine (i.e., lake) deposits. During the Jurassic Period, the area was again subject to erosion. During the Cretaceous Period, a thick sequence of Cretaceous rocks was deposited over most of the area. The Cretaceous sequence of sediments was composed of a basal clastic unit (the Trinity, Antlers, or Paluxy sands) and overlying shallow marine carbonates. Uplift from the western and southward and eastward-retreating Cretaceous seas occurred along with the Laramide Orogeny, which formed the Cordilleran Range west of the Permian Basin, per NUREG-2239.

Sediments for the nearby Late Tertiary Period Ogallala Formation came from the uplifted land associated with the Laramide Orogeny. The major episode of Laramide folding and faulting occurred in the late Paleocene Epoch; however, there have been no major tectonic events in the area since the Laramide Orogeny, per NUREG-2239.

2.5.1.4 Stratigraphy

A generalized composite stratigraphic column for the Central Basin Platform is shown in Figure 2.5-5. Individual periods of stratigraphic units are briefly described in the following subsections. The description is based primarily on the report written by Nicholson and Clebsch (Nicholson and Clebsch, 1961).

2.5.1.4.1 Precambrian Rocks (Earlier Than Approximately 570 Million Years Before Present [B.P.])

The Precambrian is the oldest recognized division of geologic time. In southern Lea County, the Precambrian rocks lie below ground surface from 7600 ft. (2317 m) on the east side to 16,800 ft. (5122 m) on the west. The Precambrian consists primarily of granitic igneous rocks which intruded older igneous and metamorphosed sedimentary rock during middle Precambrian time.

2.5.1.4.2 Paleozoic Rocks (Approximately 570 to Approximately 245 Million Years B.P.)

A thick section of Paleozoic sedimentary rocks overlies the Precambrian rocks. The Lower Ordovician is represented by the Ellenburger Group, which is a light colored cherty, crystalline dolomite. The Middle Ordovician, represented by the Simpson Group, is approximately 880 ft. to 1850 ft. (270 m to 560 m) thick and consists of three main limestone units that alternate with green shales and thin layers of sandstone and limestone. The Upper Ordovician Montoya dolomite is a cherty limestone, which is approximately 250 ft. (76 m) thick on the Central Basin Platform.

Rocks of Silurian age are represented on the Central Basin Platform by a coarse-grained crystalline glauconitic limestone approximately 180 to 200 ft. (54.9 m to 61.0 m) thick, correlative with the Middle Silurian Fusselman dolomite and overlain by 180 ft. (55 m) of green, gray, and black shales interbedded with dense limestone.

Rocks of Devonian age consist of interbedded calcareous chert and siliceous limestone, which reach a known maximum thickness of 980 ft. (300 m). The siliceous section is believed to be Late Devonian but may be Early Mississippian in age. Rocks of definite Mississippian age are absent from the area.

Rocks of Pennsylvanian age are separated from the older rocks by an erosional unconformity. On the Central Basin Platform, the rocks of Pennsylvanian age overlie the Simpson Group of Middle Ordovician age; elsewhere, they overlie rocks of Devonian age. Their thickness ranges from 1650 ft. to 2700 ft. (500 m to 820 m). The Pennsylvanian is divided into two units. The bottom unit is shale, and the top unit is limestone, gray shale, and conglomeratic red shale.

The rocks of Permian age of the area were deposited on an irregular surface formed by Late Pennsylvanian folding. The Permian rocks are divided into four series: Wolfcamp, Leonard, Guadalupe, and Ochoa. The basal Wolfcamp series has a variable thickness of as much as 440 ft. (134.1 m) of red and green shales and conglomerate. Above the Wolfcamp is the Leonard series. In the platform areas, the Leonard is represented by the Abo and Yeso Formations, which have a diverse lithology.

The Guadalupe series, above the Leonard series, is represented by the San Andres Group and the Whitehorse Group. In the subsurface on the Central Basin Platform the San Andres limestone is composed of dolomite beds with subordinate limestone members and is as thick as 1460 ft. (445.1 m). The Whitehorse Group, from 880 ft. (268.3 m) to more than 1500 ft. (457.3 m) in thickness, rests unconformably on the San Andres limestone and extends to the top of the Guadalupe series. The Whitehorse Group grades shelfward from gray, coarsely crystalline reef limestones and dolomites into buff to tan well-bedded dolomite interbedded with fine-grained sandstones and thence into alternating anhydrite, dolomite, and sandstone.

The Salado Formation of the Ochoa series is mainly halite containing some anhydrite. It ranges in thickness from 0 to approximately 2000 ft. (609.8 m). The Rustler Formation, which ranges in thickness from 90 to 360 ft. (27 m to 110 m) and consists chiefly of anhydrite, but includes red beds and salt, overlies the Salado.

2.5.1.4.3 Mesozoic Rocks (Approximately 245 to Approximately 66 Million Years B.P.)

The Triassic rocks of the area consist primarily of a sequence of red beds, the Dockum Group. The Dockum Group is divisible into Santa Rosa sandstone and the Chinle Formation. The Santa

Rosa is a fine to coarse-grained sandstone with minor shale layers that ranges in thickness from approximately 140 ft. (42.7 m) to more than 300 ft. (91.5 m). The uppermost formation of the Dockum Group is the Chinle, which ranges in thickness from 0 ft. to 1270 ft. (0 m to 387.2 m). The Chinle is dominantly red and green claystone but also contains minor fine-grained sandstone and siltstone.

There are no rocks of Jurassic age in the regional area. Rocks of Cretaceous age were deposited in Lea County but have been almost entirely removed by erosion. Only one known exposure of Cretaceous rocks exists, and this consists of large slump blocks of limestone. Individual blocks are 3 to 5 ft. (0.9 to 1.5 m) thick and are as much as 20 ft. (6.1 m) long.

2.5.1.4.4 Cenozoic Rocks (66 Million Years B.P. to Present)

The Tertiary rocks are represented by the Ogallala Formation of Pliocene age. The Ogallala Formation ranges in thickness from a few inches to approximately 300 ft. (91.5 m). It is chiefly a calcareous, unconsolidated sand, but it contains clay, silt, and gravel, with some 1 to 3 ft. (0.3 to 0.9 m) thick beds of well-consolidated, silica-cemented conglomeratic sandstone. The Ogallala on the Llano Estacado is capped by a layer of dense caliche, which ranges in thickness from a few feet to as much as 60 ft. (18.3 m). At the surface the caliche is well indurated and is almost completely calcium carbonate. Below the surface it is less well indurated, becomes softer and more porous with increasing depth, and grades into the underlying sands.

Sediments of Quaternary age are present in southern Lea County in the form of alluvial deposits, probably of both Pleistocene and Recent age, and dune sands of Recent age. The alluvium ranges in thickness from a few inches to more than 400 ft. (122.0 m), but it is generally less than 100 ft. (30.5 m) thick. It contains generally calcareous silt alternating with unconsolidated sands and some clays. The red dune sand mantles the older alluvium and the Ogallala Formation, covering approximately 80 percent of southern Lea County. The dune sands are stable or semi-stable over most of the area but are actively drifting in some places. The thickness of the dunes ranges from a few inches to 30 ft. (9.1 m), but generally the sand forms a veneer 5 to 10 ft. (1.5 to 3.0 m) thick. In areas where it is thickest, the lower part of the sand section is semi-consolidated.

2.5.2 SITE GEOLOGY

Geologic formations of interest underlying the project site are expected to be similar to those at two nearby project locations. These project locations are the URENCO uranium enrichment facility in Lea County, NM, and the CISF project location proposed by WCS in Andrews County, TX. The URENCO facility is located approximately 1.3 mi. (2.1 km) northeast of the project site; the CISF site is 3.0 mi. (4.8 km) from the project site. Geotechnical investigation results from these two nearby sites are considered representative of geologic setting, stratigraphy, and soil conditions at the EIPC project site. Site specific investigations will be performed to confirm this similarity.

2.5.2.1 Stratigraphy

According to the boring logs for the nearby sites, the deepest (oldest) geologic formation encountered is the Chinle Formation. The Chinle Formation is the uppermost unit of the Dockum Group. The Chinle Formation in the nearby borings is typically a dark red, red-brown, or purplish clay. The clay has a low moisture content, is highly plastic, and is very hard (NTS, 2005).

The next younger geologic unit identified is the Ogallala Formation of probable late Miocene to Pliocene age. The Ogallala Formation is a major regional aquifer that underlies the High Plains from the southern panhandle of Texas and adjacent New Mexico to southern South Dakota. It is believed to have developed as a depositional sand and gravel wedge built out in front of the slowly developing Rocky Mountains. The thickness of the Ogallala Formation ranges from 5 to 40 ft. (1.5 to 12 m) on the CISF site.

The Ogallala is capped by the Caprock Caliche. The Caprock Caliche is a 5- to 12-ft-thick (1.5- to 3.7-m-thick), dense bed of calcium carbonate cemented, hard, laminated limestone. It forms the resistant beds of the escarpment along the western and eastern margins of the Southern High Plains. The Caprock Caliche occurs everywhere on the CISF site.

Sedimentary formations of the Quaternary Period dominate the surficial geology, as depicted in the geologic map of the area (Figure 2.5-6). Those underlying the project site are eolian and piedmont alluvial deposits of the Holocene to middle Pleistocene Epochs. The younger surficial soils comprise the upper 35 to 40 ft. (10.7 to 12.2 m) of soil at both adjacent project locations. These formations are interlayered eolian sands and piedmont-slope sediments that are widespread deposits along the eastern flank of the Pecos River Valley, primarily between Roswell and Carlsbad. They are typically capped by thin eolian deposits. Alluvial deposits are represented immediately to the west of the project site in conjunction with the Monument Draw area (Sholle, 2003).

2.5.2.2 Site Soil Conditions

A total of 57 borings were drilled at the URENCO site, extending as deep as 100 ft. (30.5 m) (NTS, 2005). Subsurface soil conditions at the project site are described based on these boring logs considering their close proximity to the project site. Due to the close proximity, the results from the URENCO site investigation are considered representative of the EIPC site. Site specific investigations will be performed to confirm this similarity and perform seismic design of the EMIF structure.

Silty sand was encountered down to a depth of 20 ft. (6.1 m). The top 1 to 6 ft. (0.3 to 1.8 m) of soils are mostly surface eolian soil. It is very loose to loose and dry to damp. Beneath this top layer, soils become denser with depth, from medium dense to very dense conditions. At depths of approximately 10 ft. (3.0 m) to 20 ft. (6.1 m), soils show slightly plasticity. Various degrees of caliche concentration and cementation were observed in this stratum, and some of the caliche is in the form of rock fragments.

Soil, encountered from approximately 20 ft. (6.1 m) to approximately 35 ft. (11 m), is classified as Silty Sand, but more silt-like from field observations. Soils are typically dry in a powder-like condition and are mostly non-plastic. High degrees of caliche concentration and cementation were observed in this stratum. Some of the caliche is in the form of nodules and rock fragments. Gravel of various sizes spreads throughout this stratum without a pattern. Some of the gravels are caliche nodules, whereas others are not.

Encountered in the borings from depths of approximately 35 ft. (11 m) to approximately 45 ft. (14 m), soil is generally classified as Clayey Sand, but locally as Silty Clay or Clayey Gravel. These soils are typically dense to very dense, or very stiff to hard with moderate plasticity. Slight caliche concentrations and cementation were also observed in this stratum.

Highly plastic clay was then encountered at depths from approximately 40 ft. (12 m) to approximately 102 ft. (31 m) (the bottom of the deepest boring). These clay soils are generally hard, with standard penetration test N values generally over 100 blows per ft. Some round or subangular fine gravels in various colors were occasionally observed in this stratum.

Groundwater was not encountered in any of the borings, several of which were drilled to a depth of 100 ft. (30.5 m) at the site.

2.5.2.3 Non-Seismic Geological Hazards

2.5.2.3.1 Tsunamis

The EIPC project site is remote from any large body of water; furthermore, no recorded tsunamis have been reported in the vicinity surrounding the project site (NCEI, 2022g). More details on probable maximum tsunami hazards are discussed in Subsection 2.4.6. According to this subsection, there is no threat to the EIPC from tsunamis.

2.5.2.3.2 Volcanism

There are ancient volcanic regions and features in Texas within the Site Region of the EIPC, concentrated in the area between the Davis Mountains (approximately 120 mi. [193 km] southwest of the EIPC) and Big Bend National Park (approximately 220 mi. [354 km] south of the EIPC). This area is known as the Trans-Pecos Volcanic Field. However, the age of volcanic activity in the Trans-Pecos Volcanic Field is Eocene to Miocene (48 million years [Ma] to 17 Ma) (Henry and McDowell, 1986). There are no Quaternary (younger than 2.58 Ma) volcanic features in Texas (Horton, San Juan, & Stoeser, 2017).

In New Mexico, both beyond and within the Site Region, there are several volcanic fields and features that have been active during the Quaternary. The USGS ranks the relative threat level of some of these features, noted below in the descriptions, according to factors such as volcano type, explosivity, eruption recurrence, Holocene (<~12,000 years old) activity, seismicity, ground deformation, and population impacts (Ewert, Diefenbach, & Ramsey, 2018). All Quaternary features are briefly described from most distal to most proximal to the EIPC below, with more detail provided for the single volcanic feature situated within the Site Region.

a. Red Hill (Quemado) Volcanic Field, approximately 350 mi. (563 km) west-northwest of the EIPC and ranked as a very low threat by the USGS, was most recently active between 0.8 Ma and 0.0123 Ma (12,300 years) (Pleistocene) (Scholle, 2003; Ewert, Diefenbach, & Ramsey, 2018; Zimmerer, 2024; NMMNHS, 2025a).
b. Zuni-Bandera (El Malpais) Volcanic Field, approximately 325 mi. (523 km) northwest of the EIPC and ranked as a very low threat by the USGS, was active between 0.7 Ma and 0.0039 Ma (3900 years) (Pleistocene to Holocene) in McCarty's Flow (Scholle, 2003; Ewert, Diefenbach, & Ramsey, 2018; Zimmerer, 2024; NMMNHS, 2025b).
c. Jemez Volcanic Field, centered around the Valles Caldera approximately 290 mi. (467 km) to the northwest of the EIPC and ranked as a moderate threat by the USGS, was active between approximately 16 Ma and 0.0683 Ma (68,300 years) (Miocene to Pleistocene) (Scholle, 2003; Ewert, Diefenbach, & Ramsey, 2018; Zimmerer, 2024; NMMNHS, 2025c).

d. Raton-Clayton Volcanic Field (Capulin Volcano), approximately 290 mi. (467 km) north of the EIPC, was active between 9.2 Ma and 0.056 Ma (56,000 years) (Miocene to Pleistocene) (Scholle, 2003; Zimmerer, 2024; NMMNHS, 2025d).

e. Ocate (Mora) Volcanic Field, approximately 230 mi. (370 km) north-northwest of the EIPC, was active between 8.3 Ma and 0.81 Ma (Miocene to Pleistocene) (Scholle, 2003; Zimmerer, 2024; NMMNHS, 2025e).

f. Jornada del Muerto Volcano, approximately 225 mi. (362 km) west-northwest of the EIPC, was active between 2.2 Ma and 0.76 Ma (Pleistocene) (Scholle, 2003; Zimmerer, 2024; NMMNHS, 2025f).

g. Potrillo Volcanic Field, approximately 215 mi. (346 km) west of the EIPC, was active between 0.927 Ma and 0.021 Ma (21,000 years) (Pleistocene) (Scholle, 2003; Zimmerer, 2024; NMMNHS, 2025g).

h. The Carrizozo Lava Flow is the only Quaternary volcanic feature within the Site Region, located just within the radius, approximately 190 mi. (306 km) northwest of the EIPC. It is ranked as a low threat by the USGS. The Carrizozo Flow was emplaced during one continuous eruption lasting 20 to 30 years, approximately 0.0052 Ma (5200 years) (Holocene), making it the second youngest volcanism in New Mexico after the Zuni-Bandera volcanism described above. The flow originated from a broad, low basaltic shield topped by a cinder cone on the floor of the Tularosa Basin and travelled southwest 47 mi. (76 km) down the basin in one of the longest documented Holocene lava flows on Earth (Scholle, 2003; Ewert, Diefenbach, & Ramsey, 2018; Smithsonian Institution, 2022; Zimmerer, 2024; NMMNHS, 2025h).

Of the features described above, the Red Hill, Zuni-Bandera, Jemez, Raton-Clayton, and Ocate volcanic fields all occur within the Jemez Lineament, a 35- to 50-mile (56 to 80 km) wide zone of crustal weakness which crosses the northern half of New Mexico from the western border to the northeastern corner in a southwest to northeast orientation (Zimmerer, 2024). The distance of the Jemez Lineament from the EIPC site ranges from approximately 350 mi. (560 km) to the west-northwest to 250 mi. (400 km) to the north-northwest. The Jornada del Muerto Volcano, Potrillo Volcanic Field, and Carrizozo Lava Flow occur within the Rio Grande Rift, a north-south oriented crustal extensional feature active from approximately 30 Ma to present day (Oligocene to Holocene) (Morgan, Seager, & Golombeck, 1986). The Carrizozo Lava Flow is situated near the eastern boundary of the Rio Grande Rift (Zimmerer, 2024).

As stated above, the Carrizozo Lava Flow is the only Quaternary volcanic feature within the Site Region. Published maps and available literature do not document the presence of Quaternary volcanism, volcanic deposits, or other volcanic features at less than 190 mi. (306 km) distant from the Project Site. Furthermore, no documented volcanism, volcanic deposits, or other volcanic features of any age exist within the 25-mile (40 km) radius of the Site Vicinity (Scholle, 2003; Horton, San Juan, & Stoeser, 2017). Subsection 2.5.1.2 describes the EIPC site as being situated on the tectonically stable (since close of the Permian [260 Ma]) Central Basin Platform of the larger Permian Basin, underlain by carbonate reef and shallow marine clastic sedimentary rocks (Nicholson and Clebsch, 1961).

Given the distinctly different structural and depositional geologic setting of the Site Vicinity from the geologic settings of the volcano-hosting Rio Grande Rift or Jemez Lineament, the minimum distance between a Quaternary volcanic feature (Carrizozo Lava Flow) and the Site at almost the limit of the Site Region (190 mi. [304 km]), and the ranking of the Carrizozo Lava Flow as low threat by the USGS, quaternary volcanism does not pose a threat to the EIPC.

2.5.2.3.3 Slope Stability

The terrain of the project site and the surrounding area is relatively flat with no portion sufficiently sloped to permit a landslide. The nearest recorded landslide occurred east of Carlsbad but outside Lea County. No reported landslides are recorded for Lea County or nearby areas of Texas; therefore, there is no threat to the EIPC from slope instability (i.e., landslides) .

2.5.2.3.4 Karst

A karst area is generally characterized by numerous caves, sinkholes, and springs and by little surface drainage. The Guadalupe Mountains contain many caves, but few of the features are those traditionally used to define karst. The caves of the Guadalupe Mountains predate the large canyons and well-defined surface features seen today. Because the development of the caves is much older than the surrounding landscape, there are few of the typical karst features found when caves and the landscape develop simultaneously. The caves of the Guadalupe Mountains (including Carlsbad Caverns) were formed in a much different way than typical karst-forming processes, which are based on dissolution of the rock by rainwater. Between 4 million and 6 million years ago, waters rich in H_2S formed sulfuric acid, which dissolved the limestone along fractures and folds in the rock to form Carlsbad Cavern (NPS, 2022b).

Where such carbonate rocks are present at or near the surface in humid regions, units are typically karstified and contain varying densities of sinkholes, caves, and other karst features. The project site is located in a region that lacks carbonate rocks at or near the land surface (Weary and Doctor, 2014); however, evaporite basins in the subsurface (including Lea County) contain soluble rocks buried to depths of as much as 7000 ft. (2134 m), but generally much less. Because of the physical properties and high solubility of evaporite rocks (salt and anhydrites), human activities, such as fluid injection or leakage from well casings, can induce the formation of large solution voids. Collapses of these voids are known to propagate to the surface from depths of more than 1000 ft. (305 m) (Weary and Doctor, 2014).

Considering the data, there is no identified risk from karst associated with the dissolution of surface carbonate formations, but there is a minor potential for risk associated with deeper evaporative rock formations, as described below.

2.5.2.3.5 Subsidence

Oil and gas exploration and production in Lea County, NM, started in the 1920s, including in areas near Hobbs, Eunice, and Jal (Winchester, 1931). Thousands of wells have been drilled through evaporite formations to access oil and gas. Because of the extent of the evaporites (salt, anhydrite, and gypsum), drilling and completion operations must be conducted in a manner that prevents the dissolution of evaporites as well as protects the wells. There are several examples in the Permian Basin of subsidence as a result of suspected well casing corrosion and dissolution of salt. Examples of significant subsidence include Wink Sinks I and II near Wink, TX, and the Jal Sinkhole south of Eunice, NM. Wink is approximately 55 mi. (89 km) from Eunice and Jal is approximately 23 mi. (37 km) from Eunice.

Wink Sink I developed in 1980 and Wink Sink II occurred in 2002. The Jal Sink developed in 2001; it is located approximately 8 mi. (12.9 km) northwest of Jal, NM. The geologic settings of Wink Sinks I and II and the Jal Sink are similar, as they occurred at the basin margin above the Capitan Reef. Although the exact cause of development of these sinkholes is unknown, it is suspected that casing failure allowed unsaturated water to contact and subsequently dissolve

the salt layers. It is unknown whether sinkhole development was enhanced by the upward movement of water from the Capitan Reef. Rising heads could have occurred in the Capitan Reef because of lower oilfield demand for water in the 1980s and 1990s, but there is no definitive evidence that the reef was involved (AECOM, 2012).

Figure 2.5-7 shows the locations of oil and gas wells within a 1-mi. radius of the proposed project site. As shown in the figure, there are seven active oil wells, six plugged oil wells, and one active gas well. Except for three nearby plugged oil wells, all other active and plugged oil and gas wells are more than 1200 ft. (366 m) from the boundaries of the project site. Three plugged oil wells are located within approximately 600 ft. (183 m) of the boundaries of the project site. These wells were plugged and abandoned in 1970 and 1971. Cement plugs were used where the salt layer sections were encountered. After 50 years of abandonment without any indication of subsidence, these plugged wells are considered to have little risk of inducing land subsidence or sinkholes during the life of the EIPC.

As mentioned in Subsection 2.5.2, the WCS low-level waste disposal site in Andrews, TX, is approximately 2.6 mi. (4.2 km) from the project site. An evaluation of halite dissolution in the vicinity of the WCS disposal site was performed by Dr. Robert M. Holt and Dr. Dennis Powers in March 2007. This evaluation report was included as Attachment F of WCS CISF Safety Analysis Report Chapter 2 (ISP, 2021). Investigations showed that no features in the study area at and around the WCS CISF indicated any past dissolution, and the hydrologic systems at the site limit the potential for future dissolution and/or sinkholes.

Current state regulations set requirements for drilling and completion of wells that are strict compared to the processes historically used in the area. Any new wells near the proposed site must follow the latest regulations for drilling, operations, and eventual plugging or abandonment of wells (NMAC, 2008). The current regulations are designed to ensure the integrity of the borehole and to prevent the mechanisms that lead to salt dissolution.

There is no active oilfield activity within the EIPC site area, and no new oil and gas wells or land exploitation for minerals is to be allowed. Based on the above information, there is minor to no potential for sinkhole risk to the EIPC associated with oil and gas well activities, including existing plugged wells, currently active producing wells, and future well exploration and production activities.

2.5.3 SEISMICITY

The proposed project site near Eunice, NM, is in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the project site is low (IIFP, 2009).

The majority of earthquakes in the U.S. occur in the tectonically active western portion of the country; however, New Mexico can also experience earthquakes, although at a lower rate of occurrence and at lower intensities. Earthquakes in the area around the proposed project site include isolated and small clusters of low-to-moderate size toward the Rio Grande Valley of New Mexico and in Texas, southeast of the project site (IIFP, 2009).

The 2014 USGS National Hazard Maps characterized the site area as one of relatively low seismic hazard (ISP, 2021). Significant earthquakes have occurred in the region, but as is typical of the central U.S., there is a lack of Quaternary faults and few of the known earthquakes

can be associated with a specific geologic structure. Some occurrences of induced seismicity have proven to be spatially correlated to active hydrocarbon production.

Table 2.5-1 summarizes the earthquakes listed by the USGS Earthquakes Hazards Program within an approximately 100-mi. (161-km) area surrounding the project site with a magnitude of 4.0 or greater between 1950 and 2022. In total, 43 events of this magnitude were recorded during this period. A total of twelve events were recorded with magnitudes of 4.5 or greater.

2.5.4 MAXIMUM EARTHQUAKE POTENTIAL

Recorded earthquakes from 1950 through November 2022 in the approximately 100-mi. (161-km) region surrounding the project site are depicted in Figure 2.5-8 as reported by the USGS Earthquakes Hazards Program. Earthquakes are superimposed on the 2014 National Seismic Hazard Map in the figure. The USGS Earthquakes Hazards Program identifies the probability of damaging shaking to occur. Most of the earthquakes shown have low-to-moderate magnitudes (between 2.5 and 5.0). The largest recorded event within 100 mi. (161 km) between 1950 and November 2022 was a magnitude 5.4 event located in Coalson Draw, TX, approximately 25 mi. (40 km) west of Mentone, TX (USGS, 2023). The two closest events to the project site include a magnitude 3.3 event in 2001 that occurred 6.8 mi. (11 km) south of Eunice and a magnitude 4.6 event in 1992 that occurred 7.5 mi. (12 km) south-southeast of Eunice.

2.5.5 VIBRATORY GROUND MOTION

Seismic demands for the EMIF are determined to meet the target performance goal of 1.0E-4 annual probability of exceeding a limit state for the SDC-3 safety-related structures as defined in ANSI/ANS-2.26-2004, Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design (R2021) (ANSI/ANS, 2021). To estimate levels of earthquake ground shaking, the 2023 USGS National Seismic Hazard Model available via the USGS Earthquake Hazard Toolbox is used to determine the site Uniform Hazard Response Spectra (UHRS) for a site classification C with 10,000-year return period and 1000-year return period (USGS, 2025). The peak ground accelerations (PGA) for the UHRS with return periods of 10,000 years and 1000 years are 0.188 g and 0.029 g, respectively (where g is the standard acceleration due to gravity). Site classification C is adopted based on the URENCO site and CISF project site investigations. The site classification will be confirmed as part of the site-specific investigations.

The horizontal Design Response Spectrum (DRS) is determined using the 10,000-year and 1000-year return period UHRS following the procedure in ASCE/SEI 43-19, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities (ASCE/SEI, 2020). A bounding constant scale factor of 0.5 is conservatively applied to the 10,000-year return period UHRS. The developed horizontal DRS is provided in Figure 2.5-9 and Table 2.5-2 along with the 10,000-year and 1000-year return period UHRS. The PGA of the horizontal DRS is 0.094 g.

The DRS in the vertical direction is determined based on EPRI Report 3002004396, High Frequency Program – Application Guidance for Functional Confirmation and Fragility Evaluation (EPRI, 2015). Appendix A of the document provides guidance to develop generic vertical-to-horizontal (V-H) ratios of the DRS. The V-H ratios for sites with the Vs30 higher than 400 m/s (895 mph) are lower than 1.0 for all frequency ranges of interest. For the design of the EMIF, the vertical DRS is conservatively taken as the same as the horizontal DRS presented in Figure 2.5-9 and Table 2.5-2. The vertical DRS will be confirmed after the site-specific investigations are performed.

2.5.6 SURFACE FAULTING

Two types of faulting were associated with early Permian deformation. Most faults were long, high-angle reverse faults with several hundred feet of vertical displacement that often involved Precambrian basement rocks. The second type of faulting is found along the western margin of the Central Basin Platform where long strike-slip faults, with displacements of tens of miles, are found. All the major faulting in the vicinity of the Central Basin Platform occurred in response to tectonic forces active before the global plate tectonic reorganization that created the North American continent. The Paleozoic faults exhibit low natural microseismicity as a result of passive response to relatively low levels of tectonic stress in the trailing edge of the westward-drifting North American Plate. The closest Quaternary faults are in the Guadalupe Mountains, approximately 100 mi. (160 km) to the southwest (ISP, 2021).

The large structural features of the Permian Basin are reflected only indirectly, as there has been virtually no tectonic movement within the basin since the Permian. The Central Basin Platform is located approximately 7000 ft. (2130 m) beneath the present land surface with Permian and Triassic sediments over the platform structure. The faults that uplifted the platform do not appear to displace the younger Permian sediments (ISP, 2021).

Regional geologic and tectonic information does not indicate the presence of significant post-Permian faulting within the area. Post-Permian activity in the entire Permian Basin consisted of localized tectonic pulses, and the basin has remained stable for the last 200 million years (ISP, 2021).

The closest Quaternary faults associated with the southwestern base of the Guadalupe Mountains are distant from the project site. The closest such fault is unnamed, No. 907, located at the base of the Guadalupe Mountains in Guadalupe Mountains National Park in Culberson County, TX, approximately 109 mi. (175 km) from the project site. This is a normal fault with the most recent deformation estimated at less than 1.6 million years ago. A second fault associated with this region is Guadalupe Fault No. 2058, in Chaves and Otero counties, New Mexico; this fault is interpreted to have been active in the last 15,000 years (Machette and Jochems, 2015). Additional Quaternary Age faults are located south of the two previously mentioned faults along the southwestern base of the Guadalupe Mountains in Texas. The next closest area of Quaternary Age faulting is the Alamogordo Fault, which is divided into three sections. The sections of the Alamogordo Fault closest to the project site are located west in Otero County, New Mexico, with the most recent deformation estimated at less than 130,000 years ago, per NUREG-2239.

2.5.7 LIQUEFACTION POTENTIAL

No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction at the project site is low (IIFP, 2009). In addition, based on data from private wells within 1 mi. (1.6 km) of the project site, the depth to groundwater in the project vicinity ranges from 16 ft. to 241 ft. (4.8 m to 73.5 m). Data from these wells indicate that groundwater at the project site generally flows to the northwest. Localized, shallow groundwater exists in the vicinity of the project site, near the Wallach Concrete, Inc., and Sundance Services, Inc., properties to the northeast; however, this localized subsurface saturation is limited. This saturated zone is characterized by discontinuity and low permeability, suggesting that this groundwater is a perched water condition and not an aquifer, per NUREG 1790. At the nearby URENCO site (approximately 1.3 mi. [2.1 km] northeast) there is no documented potential for soil liquefaction by the design basis earthquake. Soil depths up to 100 ft. (31 m) are dry, damp, or moist and groundwater may be at

a depth of 600 ft. (183 m). These subsurface soil and groundwater conditions indicate there is no potential for liquefaction at the URENCO site (URENCO, 2010). Considering the close proximity of the URENCO site, similar soil and groundwater conditions are likely present at the EIPC project site.

Therefore, the soil and groundwater conditions necessary for liquefaction to occur are unlikely to be present at the EIPC project site.

2.5.8 CONCLUSIONS

The project site is located on the Central Basin Platform, which is one major structural element of the Permian Basin. The Central Basin Platform is composed of carbonate reef deposits and shallow marine clastic deposits. Geotechnical investigation results from two nearby sites are considered representative of subsurface conditions at the project site. Site-specific investigations will be performed to confirm this similarity.

Non-seismic geological hazards are discussed above. There are no threats to the proposed site from tsunamis, volcanism, or landslides. There is no identified risk from karst associated with the dissolution of surface carbonate formations, but there is some minor potential for risk at the proposed site associated with the dissolution of deeper evaporative rock formations.

Significant earthquakes have occurred in the area, but the proposed project site lies in a generally quiet seismic region with relatively low seismic hazard. The largest recent earthquake (during the period 1950 to 2022) to occur within 100 mi. (160 km) of the site was a magnitude 5.4 earthquake located approximately 74 mi. (120 km) to the southwest. The project site region is typical of the central U.S. with a lack of Quaternary faults, and few of the known earthquakes can be associated with a specific geologic structure. The closest Quaternary faults are located approximately 100 mi. (160 km) to the southwest in the Guadalupe Mountains (ISP, 2021).

The site DRS are determined based on geotechnical information from the URENCO site. A site-specific investigation will be performed to confirm the site conditions are consistent with the URENCO site.

Based on nearby subsurface soil and groundwater conditions, liquefaction potential is low and is unlikely to occur at the project site during a design basis earthquake.

Table 2.5-1
(Page 1 of 2)
Recorded Earthquakes (Magnitude of 4.0 or Greater) from 1950 to 2022

Year	Latitude	Longitude	Depth (km)	Magnitude	Location
1975	31.425	-104.012	5.0	4.8	24 km WNW of Toyah, TX
1992	32.336	-103.101	5.0	4.6	12 km SSE of Eunice, NM
1999	32.591	-104.630	1.0	4	26 km SSE of Hope, NM
2004	32.525	-104.566	5.0	4	31 km SSW of Atoka, NM
2005	32.528	-104.549	5.0	4.1	30 km SSW of Atoka, NM
2010	32.438	-104.501	4.0	4.1	25 km W of Carlsbad, NM
2010	32.524	-104.607	5.0	4	33 km SSE of Hope, NM
2020	31.717	-104.042	9.5	5	41 km W of Mentone, TX
2020	32.295	-101.794	5.0	4	18 km N of Stanton, TX
2021	31.654	-101.774	6.2	4.5	57 km S of Whites City, NM
2021	31.663	-104.357	7.4	4	56 km S of Whites City, NM
2021	31.664	-104.030	6.1	4.4	56 km S of Whites City, NM
2021	32.071	-104.371	7.8	4	37 km ESE of Malaga, NM
2021	31.609	-104.003	6.3	4.3	54 km NW of Toyah, TX
2021	31.665	-104.258	6.8	4.3	56 km S of Whites City, NM
2021	31.672	-104.313	6.1	4.3	55 km S of Whites City, NM
2021	31.597	-104.400	7.3	4.1	36 km NNW of Toyah, TX
2021	31.593	-104.377	8.8	4.3	36 km NNW of Toyah, TX
2021	31.673	-104.380	6.1	4.2	55 km S of Whites City, NM
2021	31.706	-104.001	8.1	4	40 km W of Mentone, TX
2021	31.722	-104.370	7.3	4	52 km SSW of Whites City, NM
2021	31.565	-104.024	8.5	4.4	35 km NW of Toyah, TX
2021	32.286	-104.517	8.4	4.6	17 km N of Stanton, TX
2022	31.674	-103.719	7.4	4.2	55 km S of Whites City, NM
2022	31.660	-104.420	7.4	4.3	57 km S of Whites City, NM
2022	31.586	-104.385	6.2	4	65 km NNE of Van Horn, TX
2022	31.669	-104.567	6.8	4.6	56 km S of Whites City, NM
2022	31.614	-103.977	9.3	4	37 km WSW of Mentone, TX
2022	31.615	-103.971	8.8	4	36 km WSW of Mentone, TX
2022	31.600	-103.982	9.6	4.3	western TX
2022	31.715	-104.551	6.2	4.6	53 km SSW of Whites City, NM

Table 2.5-1
(Page 2 of 2)
Recorded Earthquakes (Magnitude of 4.0 or Greater) from 1950 to 2022

Year	Latitude	Longitude	Depth (km)	Magnitude	Location
2022	31.719	-104.539	5.3	4.3	52 km SSW of Whites City, NM
2022	31.658	-104.518	7.5	4.1	58 km SSW of Whites City, NM
2022	31.680	-104.421	5.9	4.9	55 km S of Whites City, NM
2022	31.674	-104.383	7.2	4.2	55 km S of Whites City, NM
2022	31.683	-104.425	6.6	4.5	54 km S of Whites City, NM
2022	31.625	-103.989	6.6	4.4	38 km WSW of Mentone, TX
2022	31.592	-104.002	6.2	4.1	36 km NNW of Toyah, TX
2022	31.637	-103.999	6.9	5.4	Coalson Draw, TX
2022	31.629	-104.009	8.1	4	39 km WSW of Mentone, TX
2022	31.635	-104.002	7.5	4	38 km WSW of Mentone, TX
2022	31.634	-103.988	7.4	4.5	western Texas
2022	31.627	-104.003	8.5	4.7	34 km WSW of Mentone, TX

Abbreviations: km = kilometers | WNW = west-northwest | TX = Texas |SSE = south-southeast | NM = New Mexico | SSW = south-southwest | W = west | N = north | S = south | ESE= east-southeast | NW = northwest | NNW = north-northwest | NNE = north-northeast | WSW = west-southwest

Table 2.5-2
Uniform Hazard and Design Response Spectra at Surface Elevation

Frequency (Hz)	10,000 year (g)	1000 year (g)	DRS (g)
0.1	0.004	0.001	0.002
0.13	0.007	0.002	0.003
0.2	0.011	0.003	0.006
0.25	0.015	0.004	0.008
0.33	0.022	0.006	0.011
0.5	0.035	0.010	0.018
0.67	0.047	0.013	0.023
1	0.070	0.020	0.035
1.33	0.093	0.027	0.047
2	0.128	0.036	0.064
2.5	0.150	0.040	0.075
3.33	0.185	0.046	0.093
4	0.216	0.050	0.108
5	0.262	0.057	0.131
6.67	0.336	0.067	0.168
10	0.386	0.068	0.193
13.33	0.397	0.065	0.199
20	0.376	0.056	0.188
33.33	0.310	0.044	0.155
50	0.259	0.037	0.130
100	0.188	0.029	0.094

Abbreviations: Hz – hertz | g = standard acceleration due to gravity | DRS = Design Response Spectrum

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Figure 2.1-1
Site Vicinity

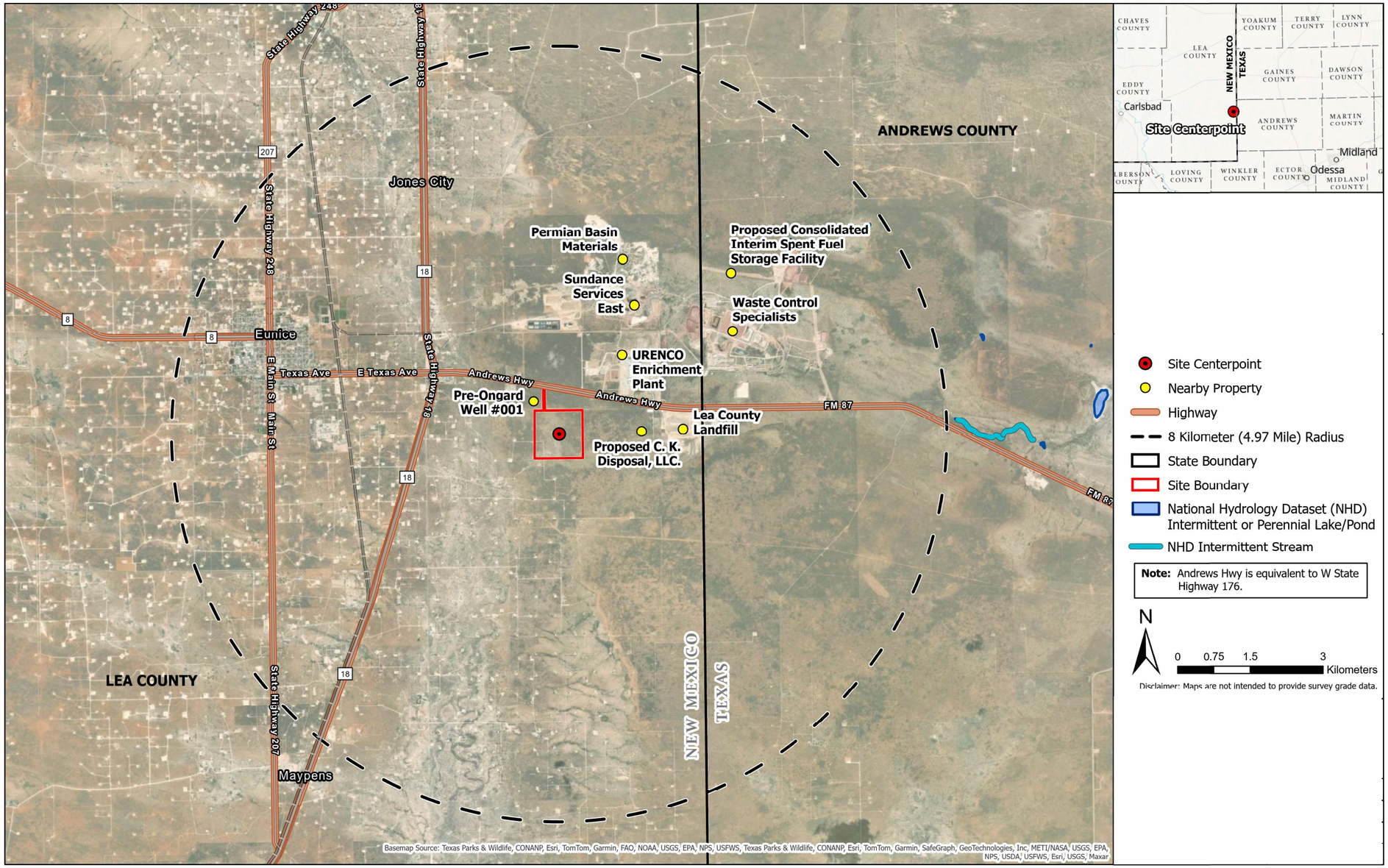

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Figure 2.1-2
Boundaries and Zones Associated with the EIPC

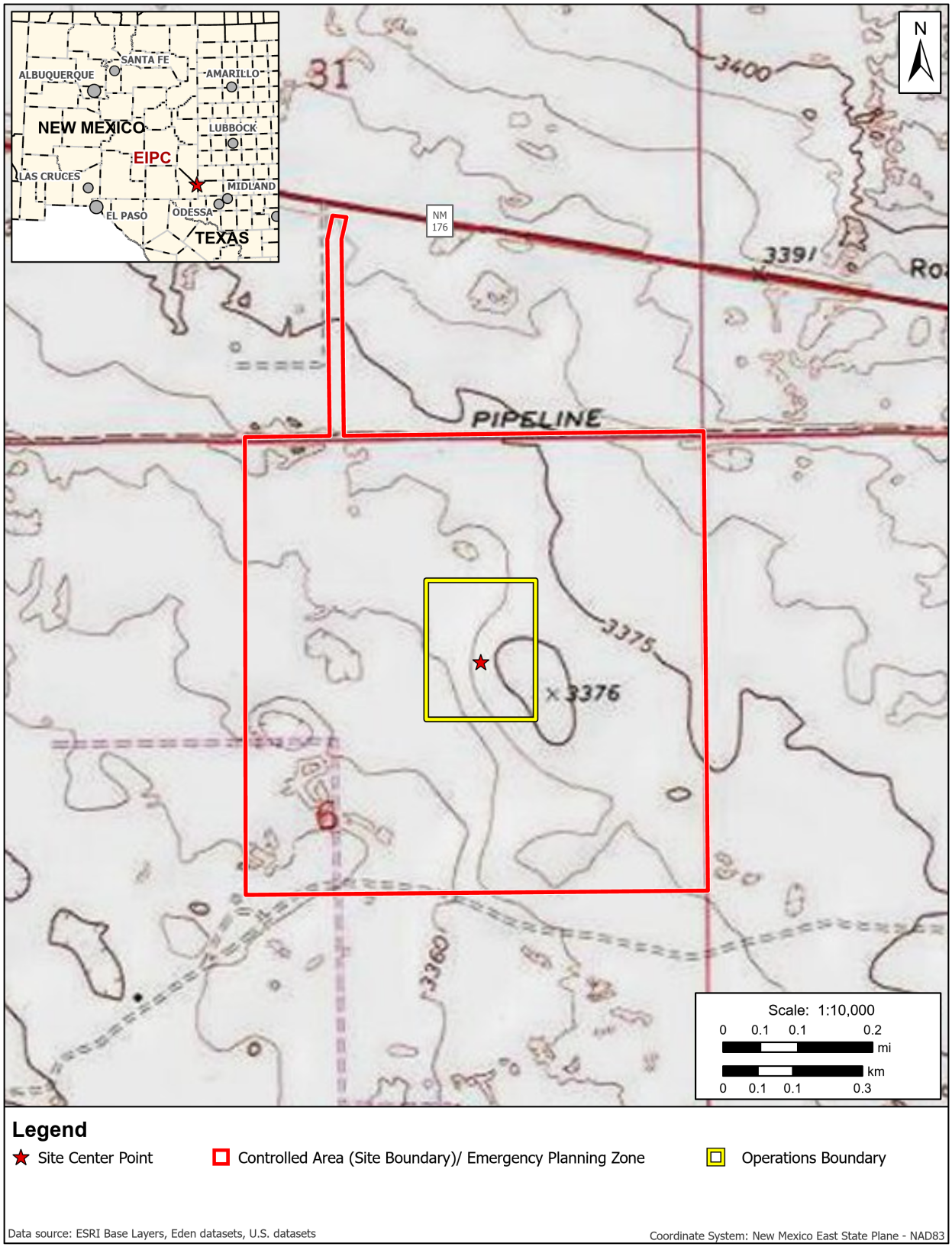


Figure 2.1-3
Distance Bands and Directional Sectors

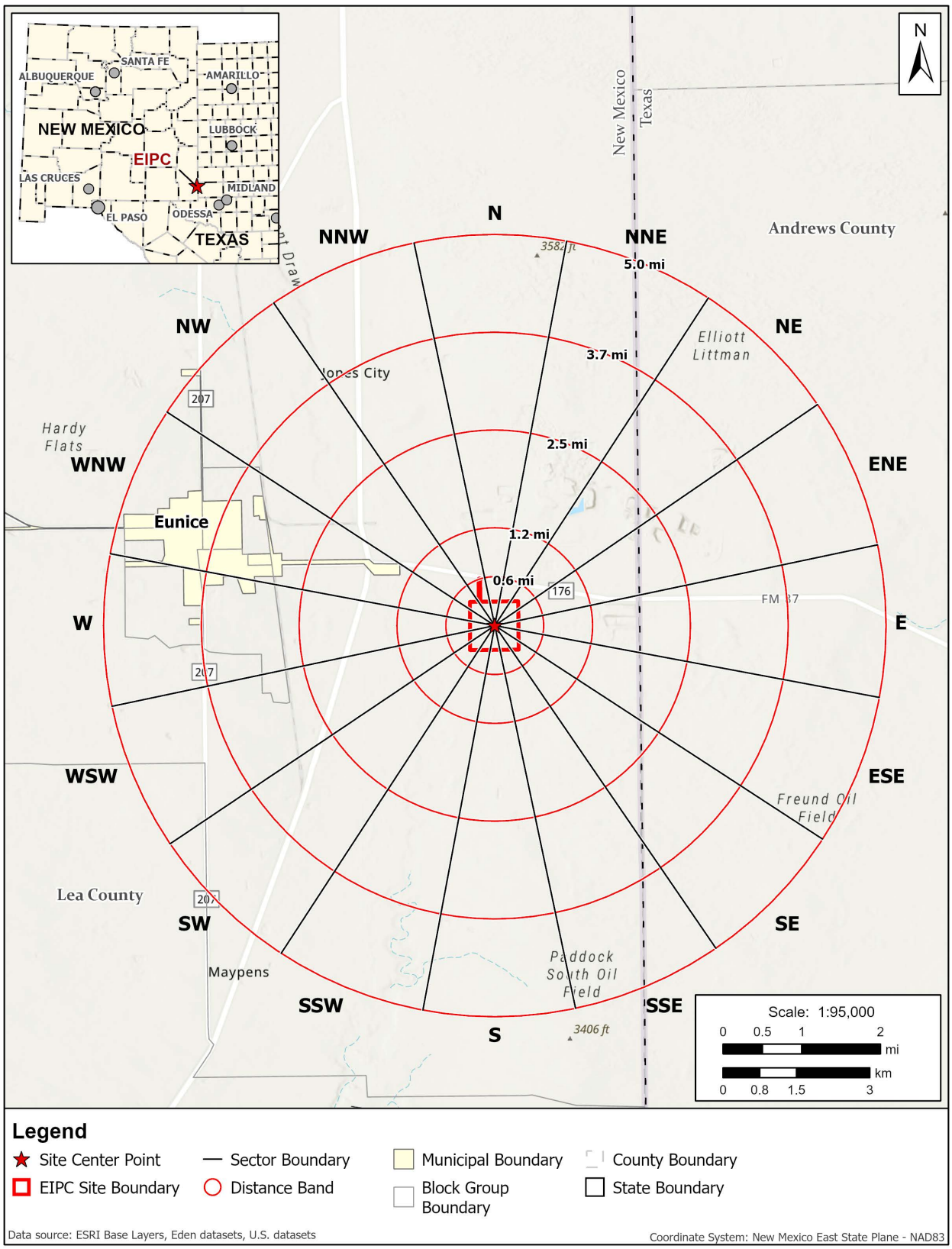


Figure 2.1-4
Resident Population Distribution — 2020

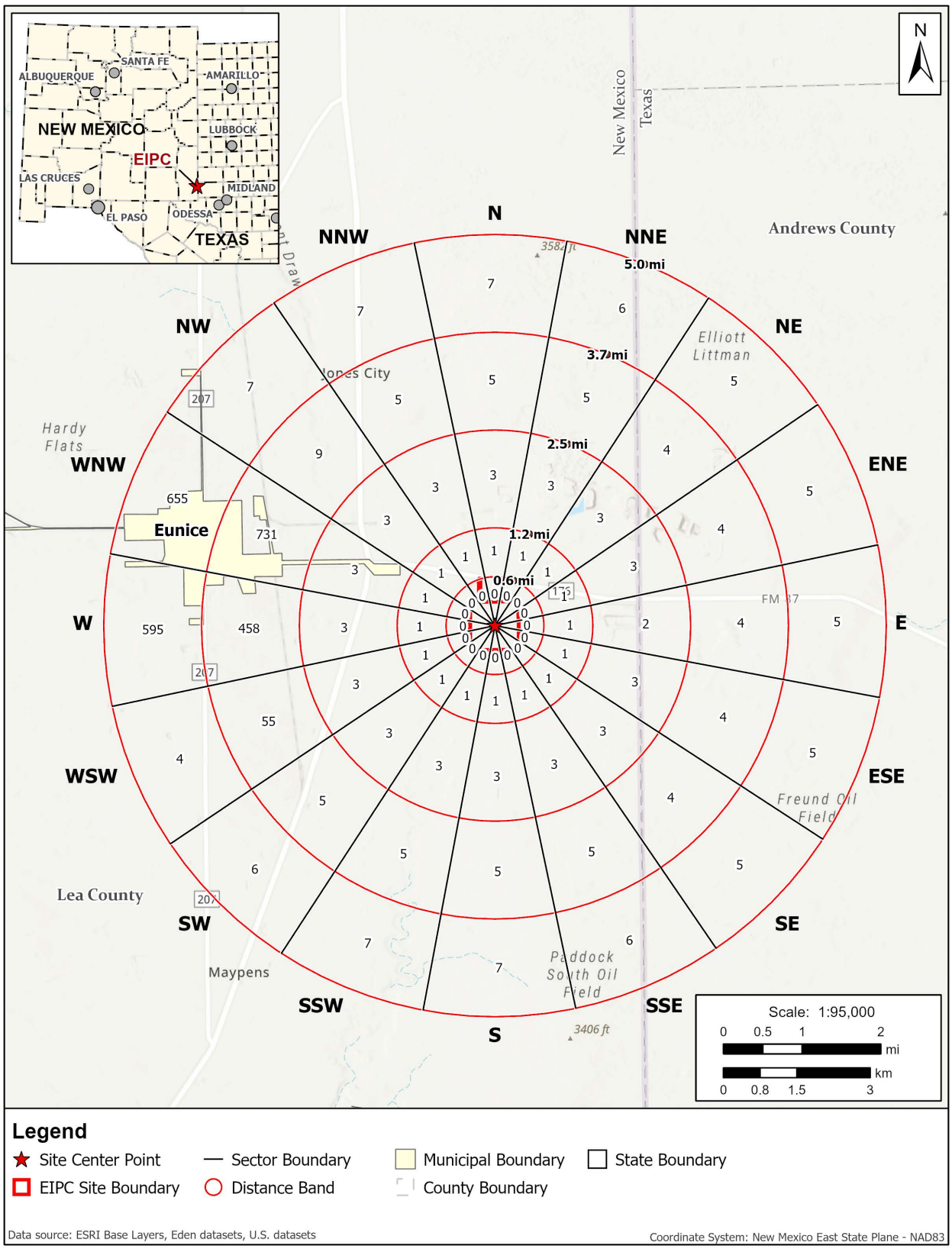
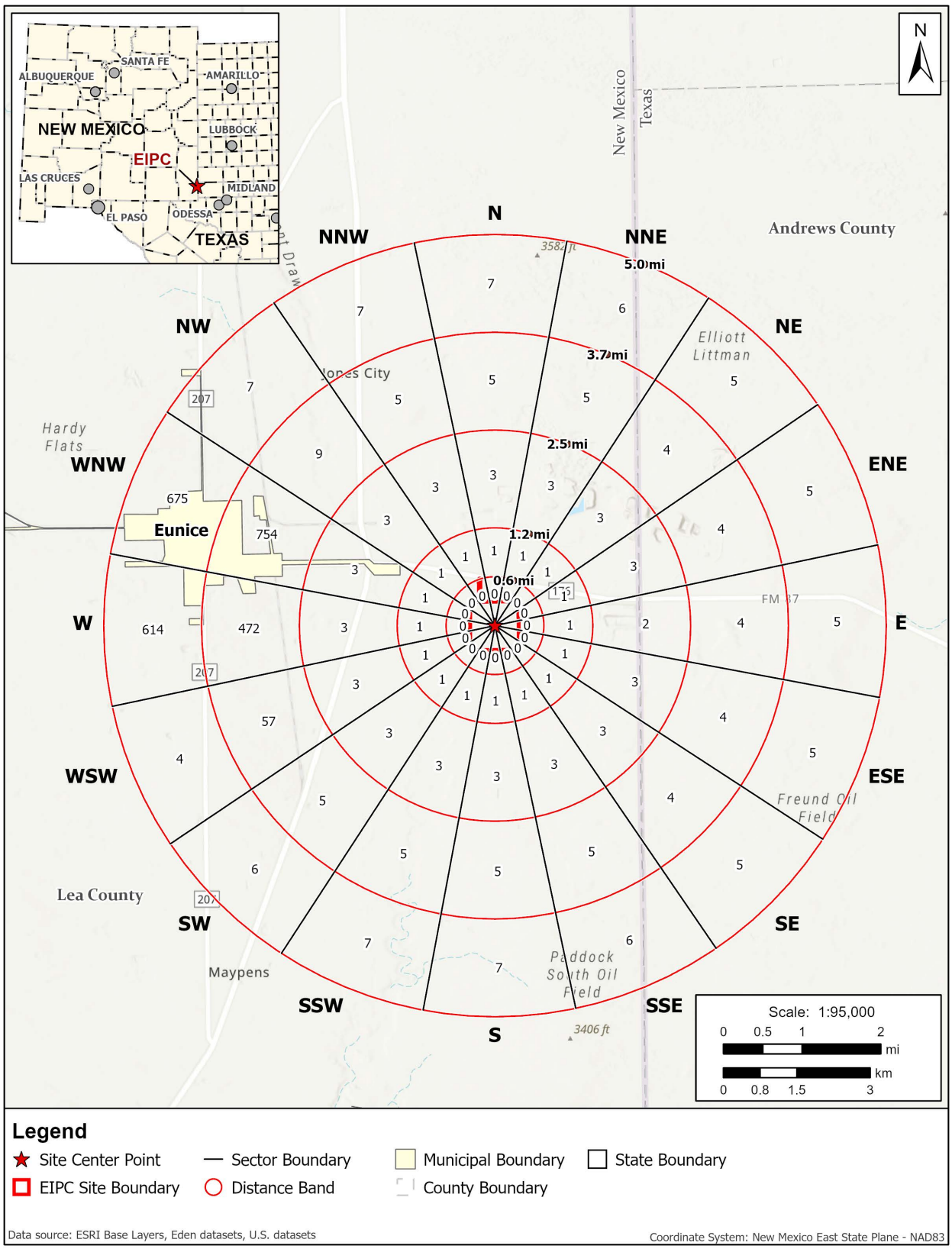


Figure 2.1-5
Resident Population Distribution — 2023



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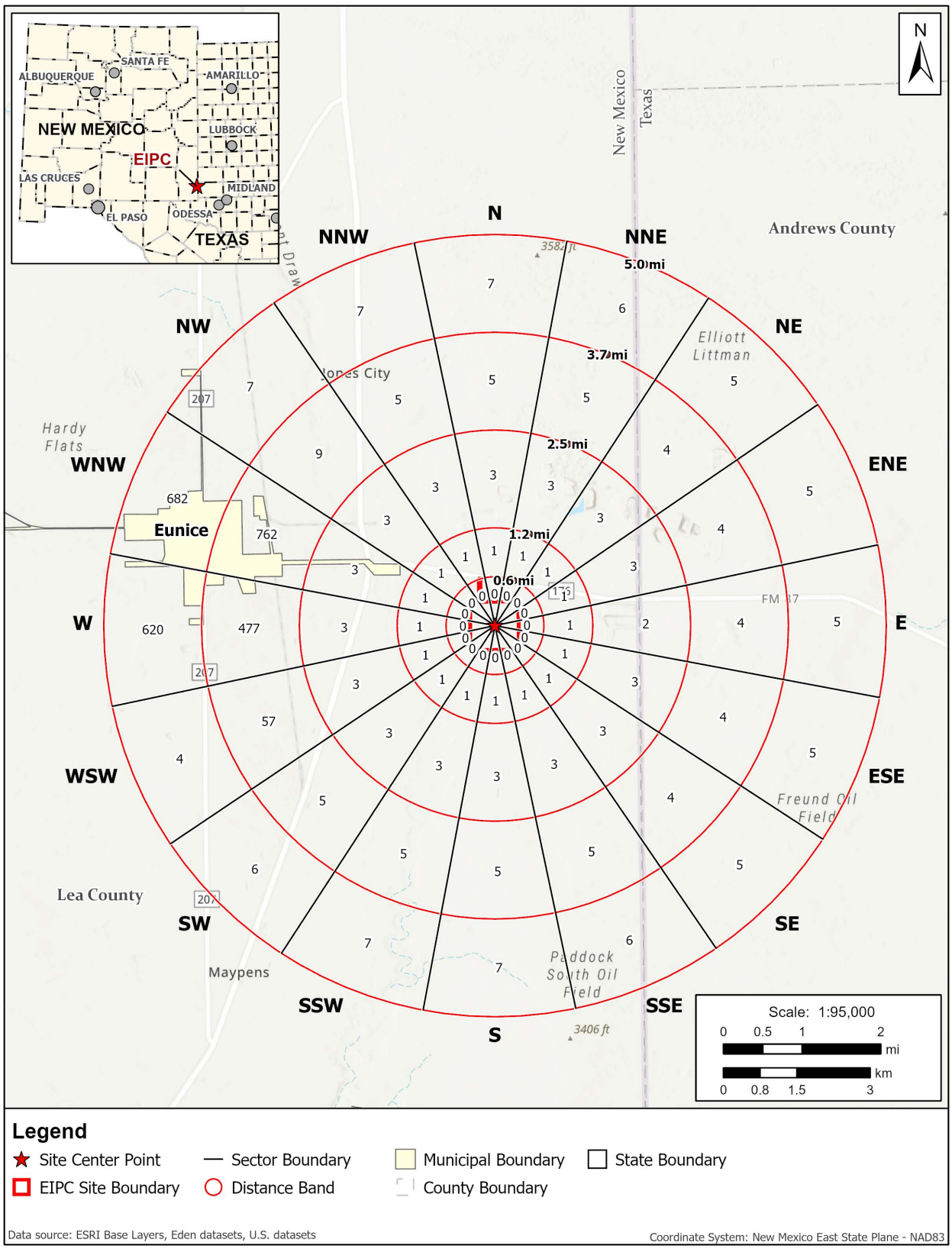
Resident Population Distribution — 2024



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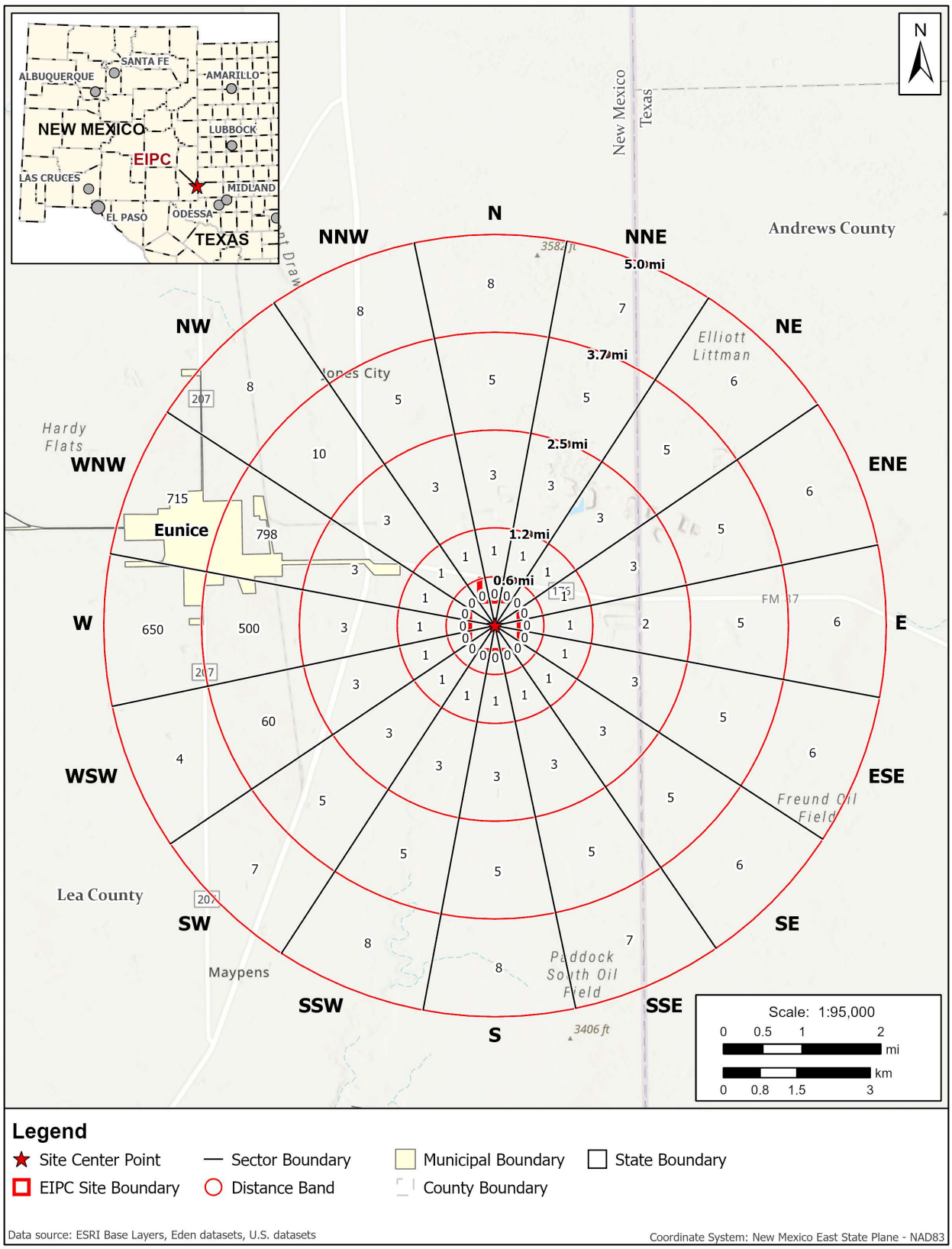
Resident Population Distribution — 2029



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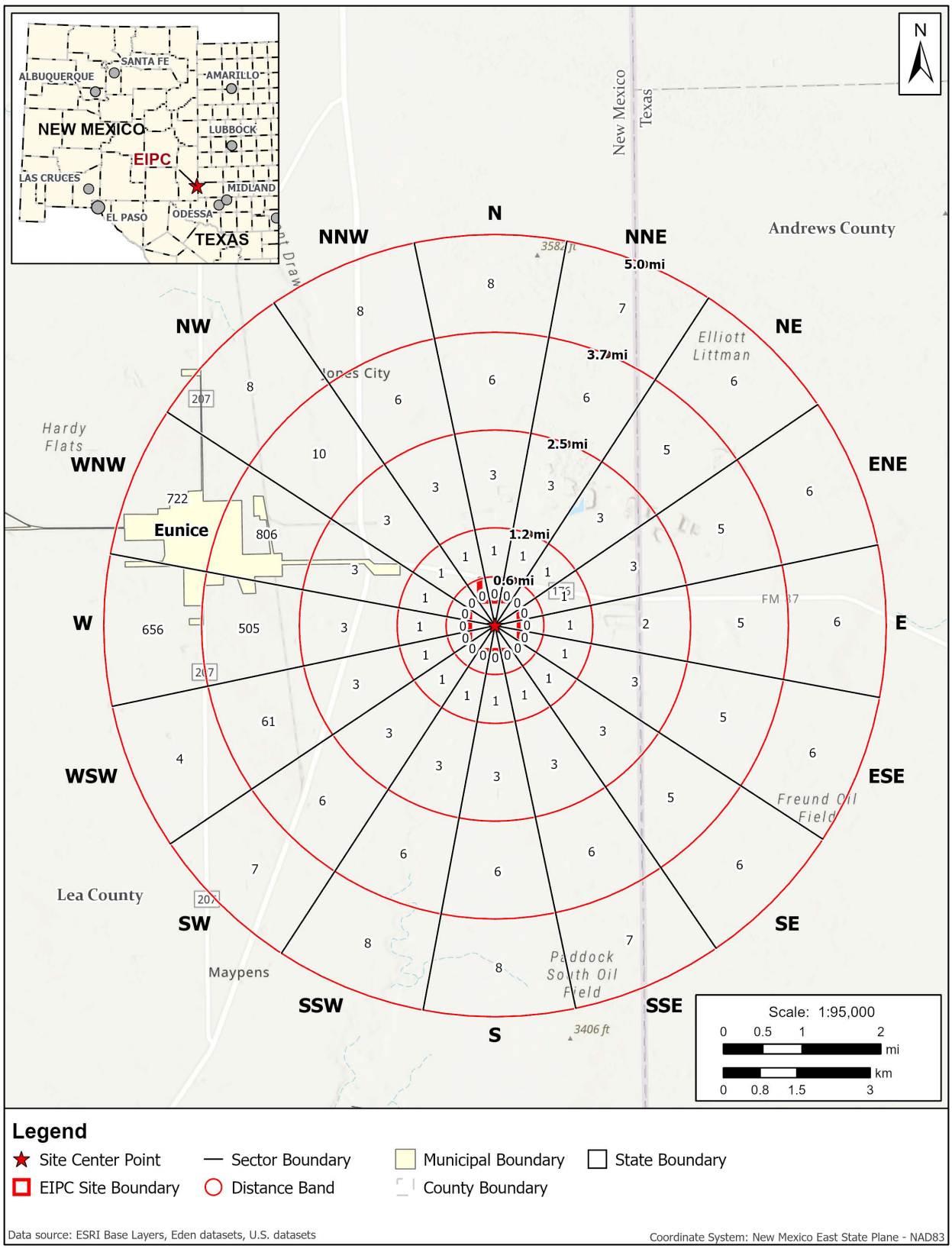
Resident Population Distribution — 2030



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Resident Population Distribution — 2040

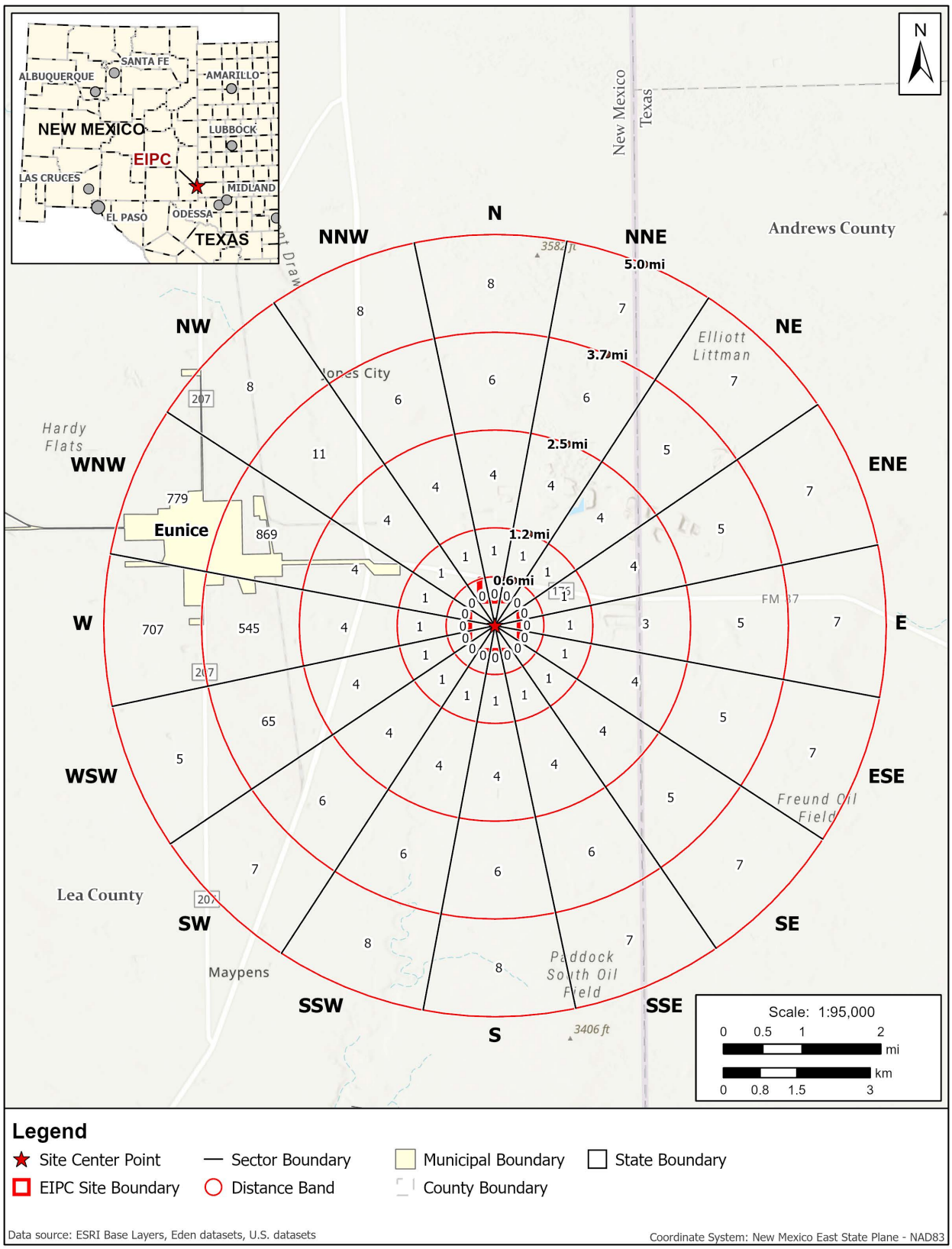
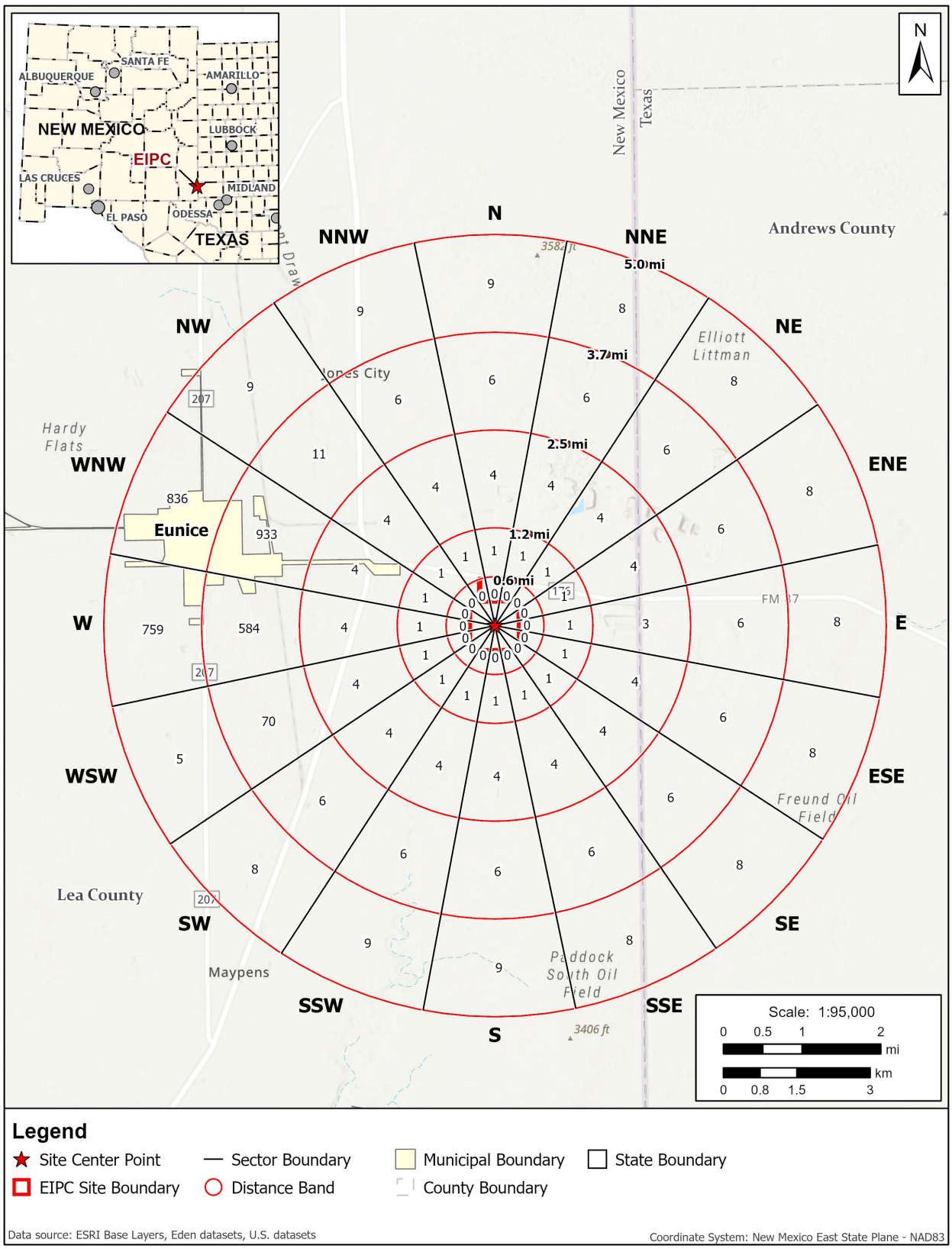


Figure 2.1-10
Resident Population Distribution — 2050



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Resident Population Distribution — 2060

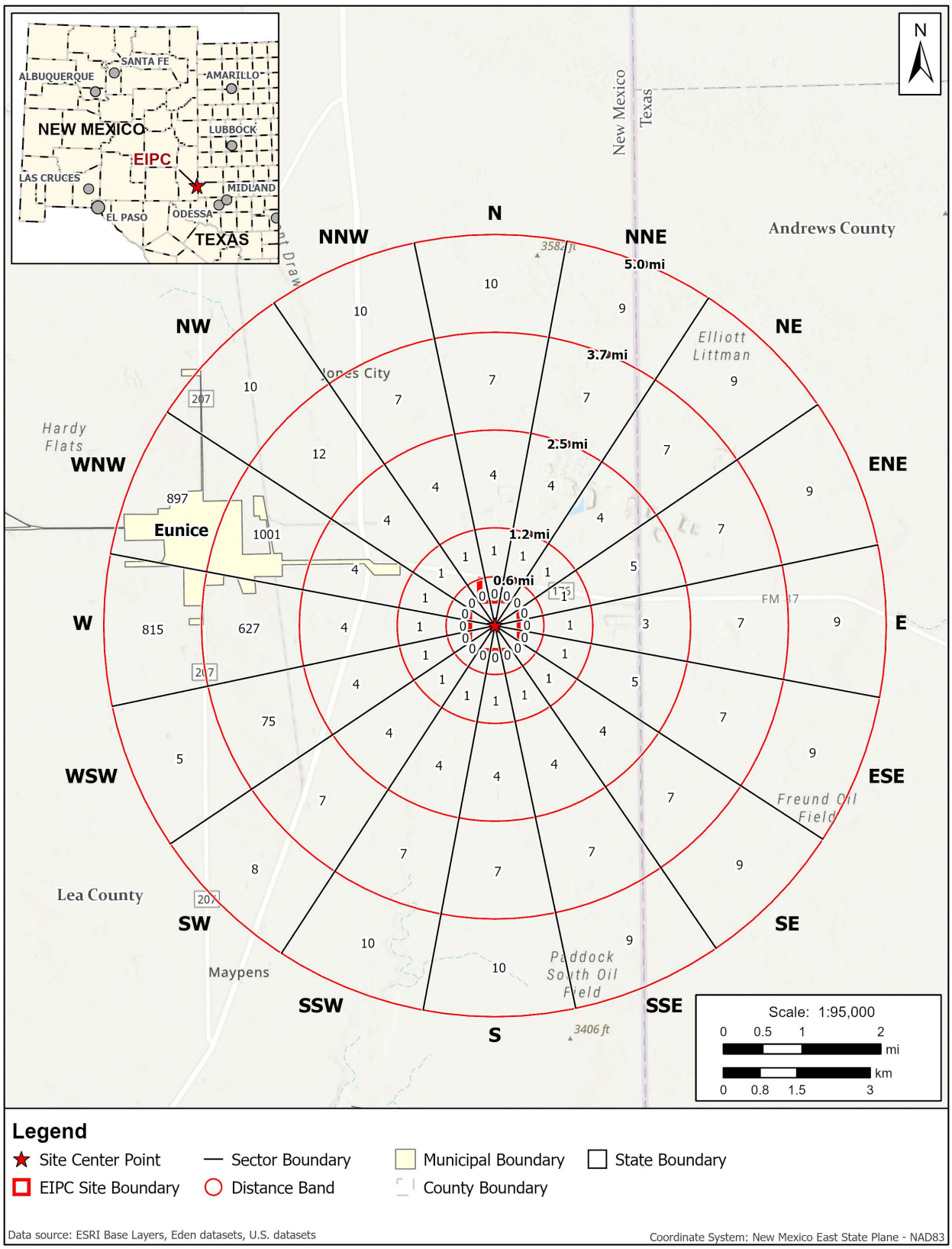


Figure 2.1-12
Resident Population Distribution — 2070

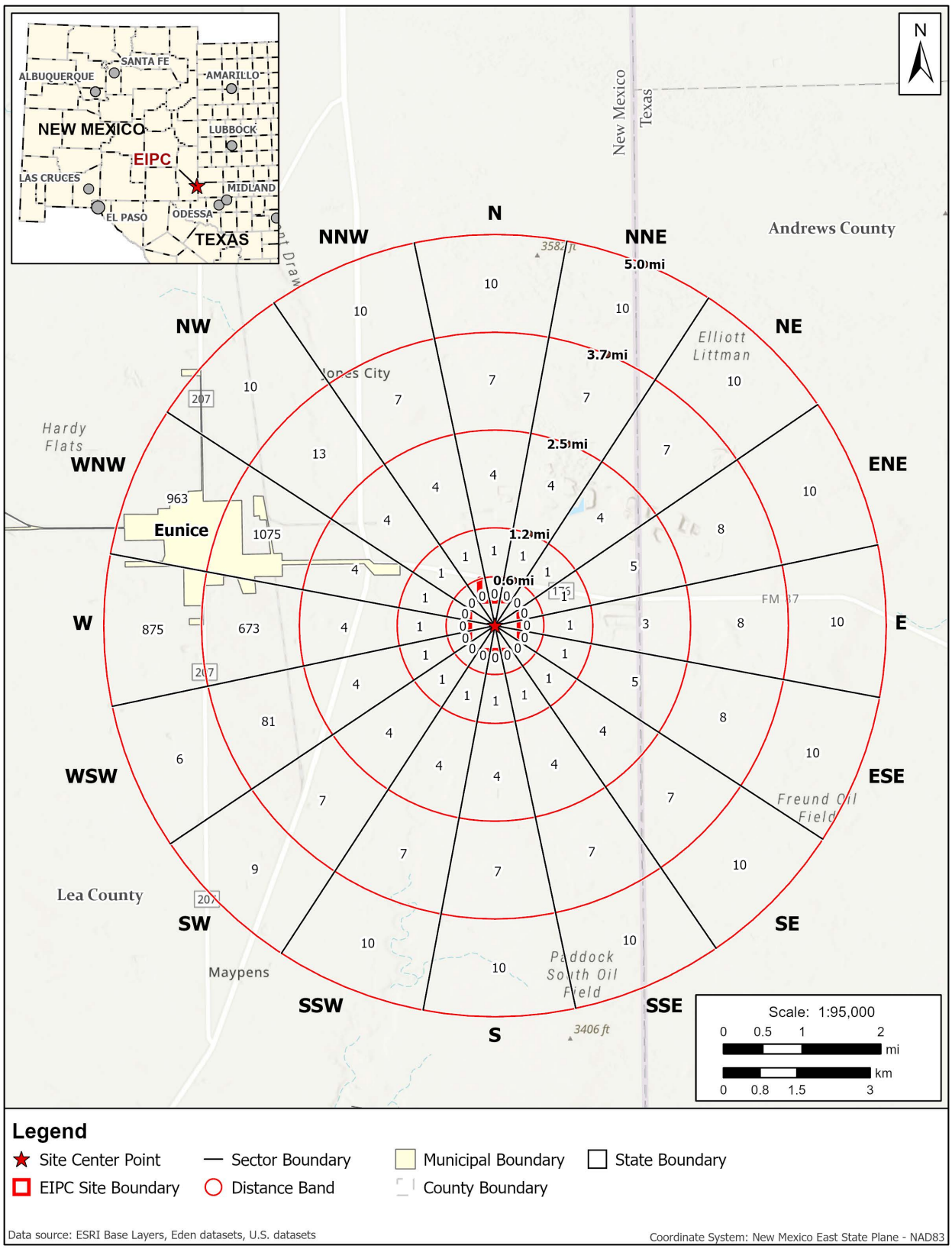
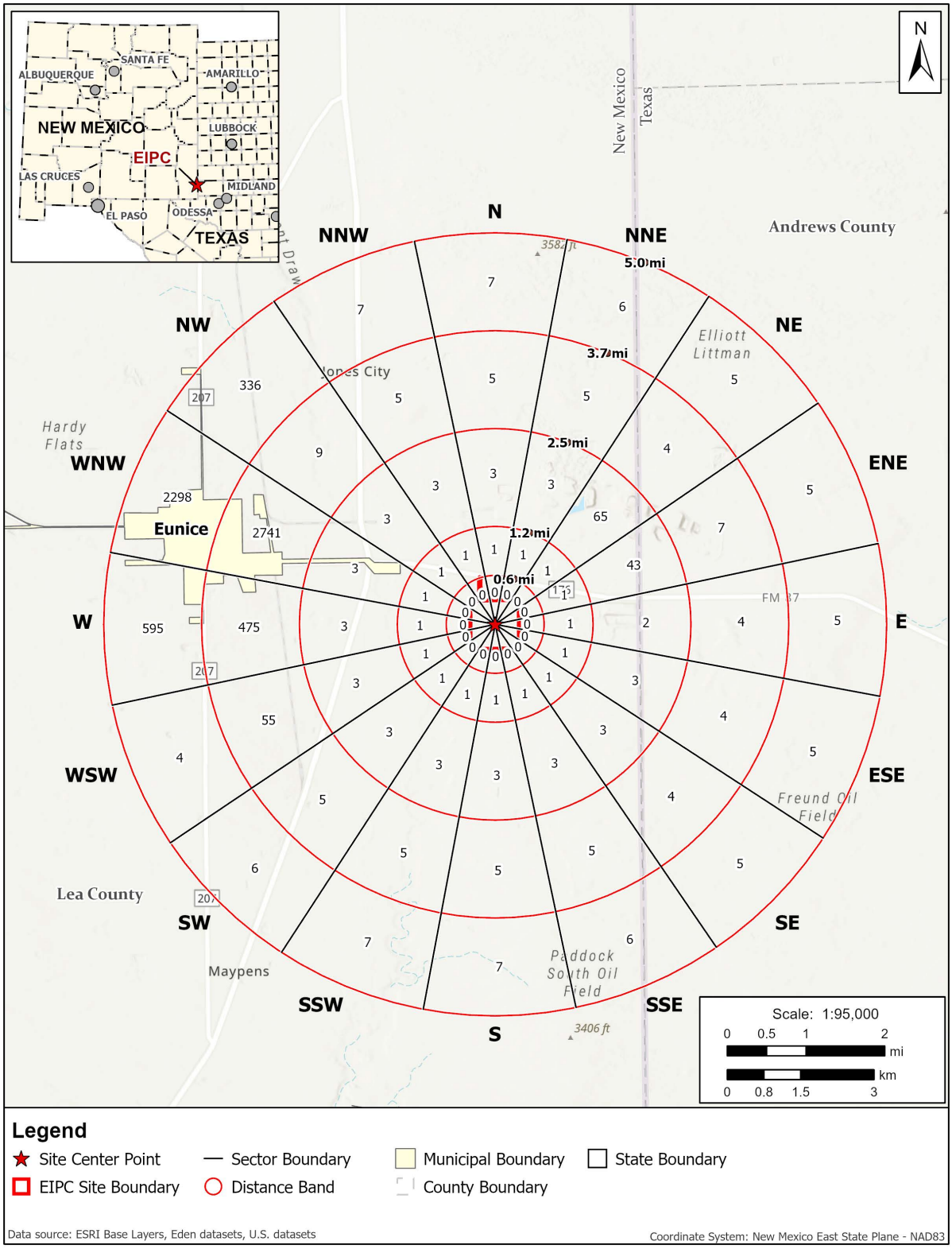


Figure 2.1-13
Combined Resident and Transient Population Distribution — 2020



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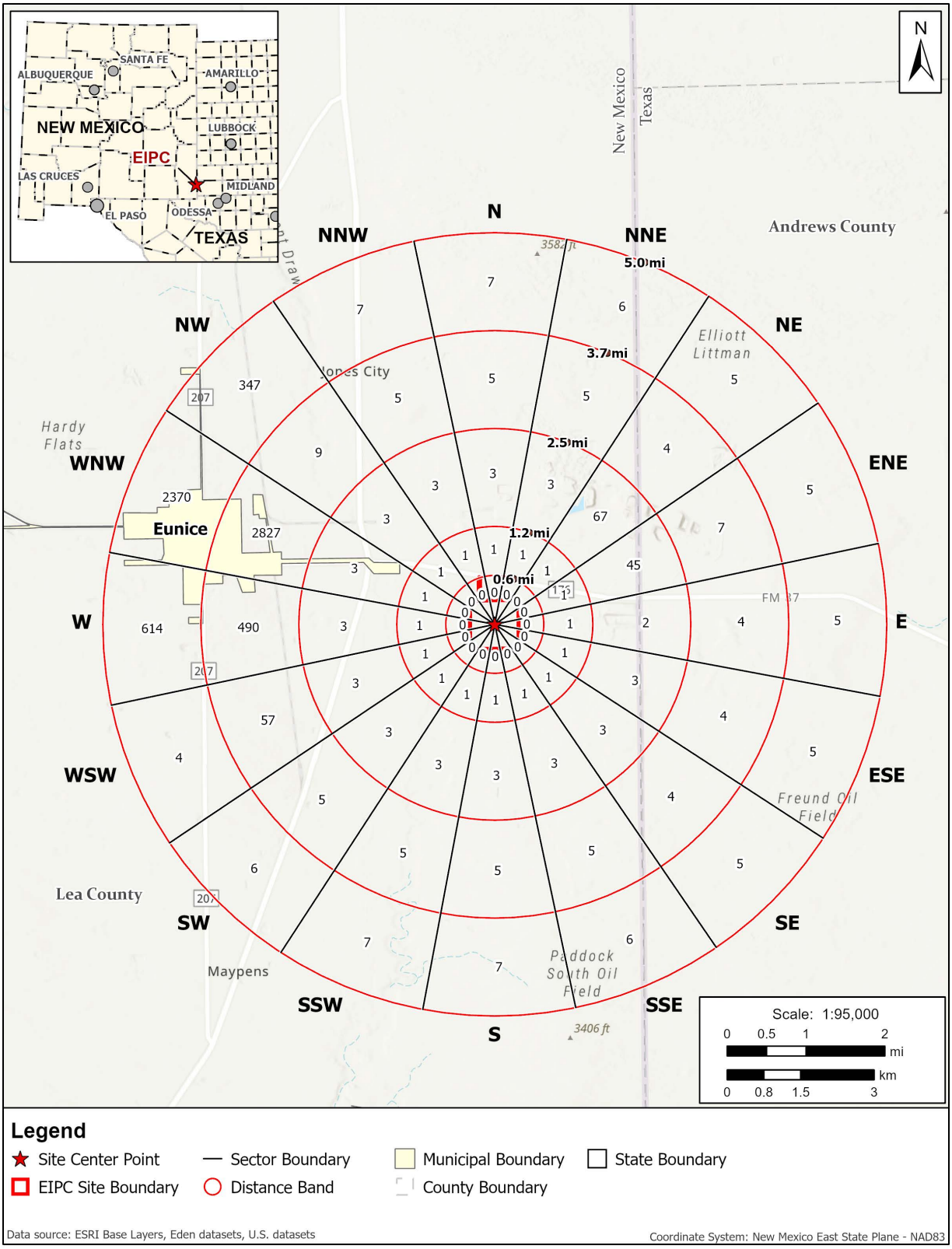
Combined Resident and Transient Population Distribution — 2023



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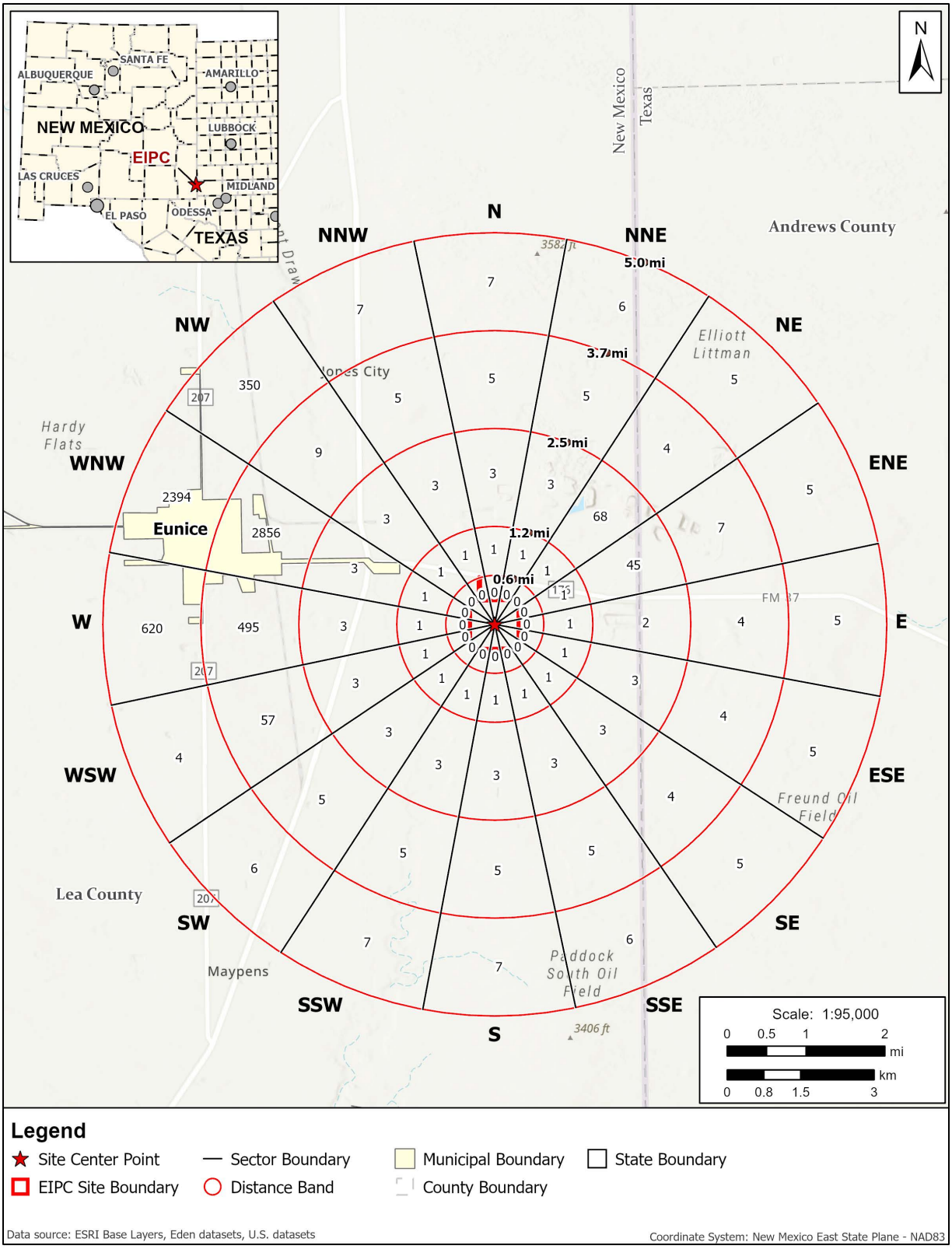
Combined Resident and Transient Population Distribution — 2024



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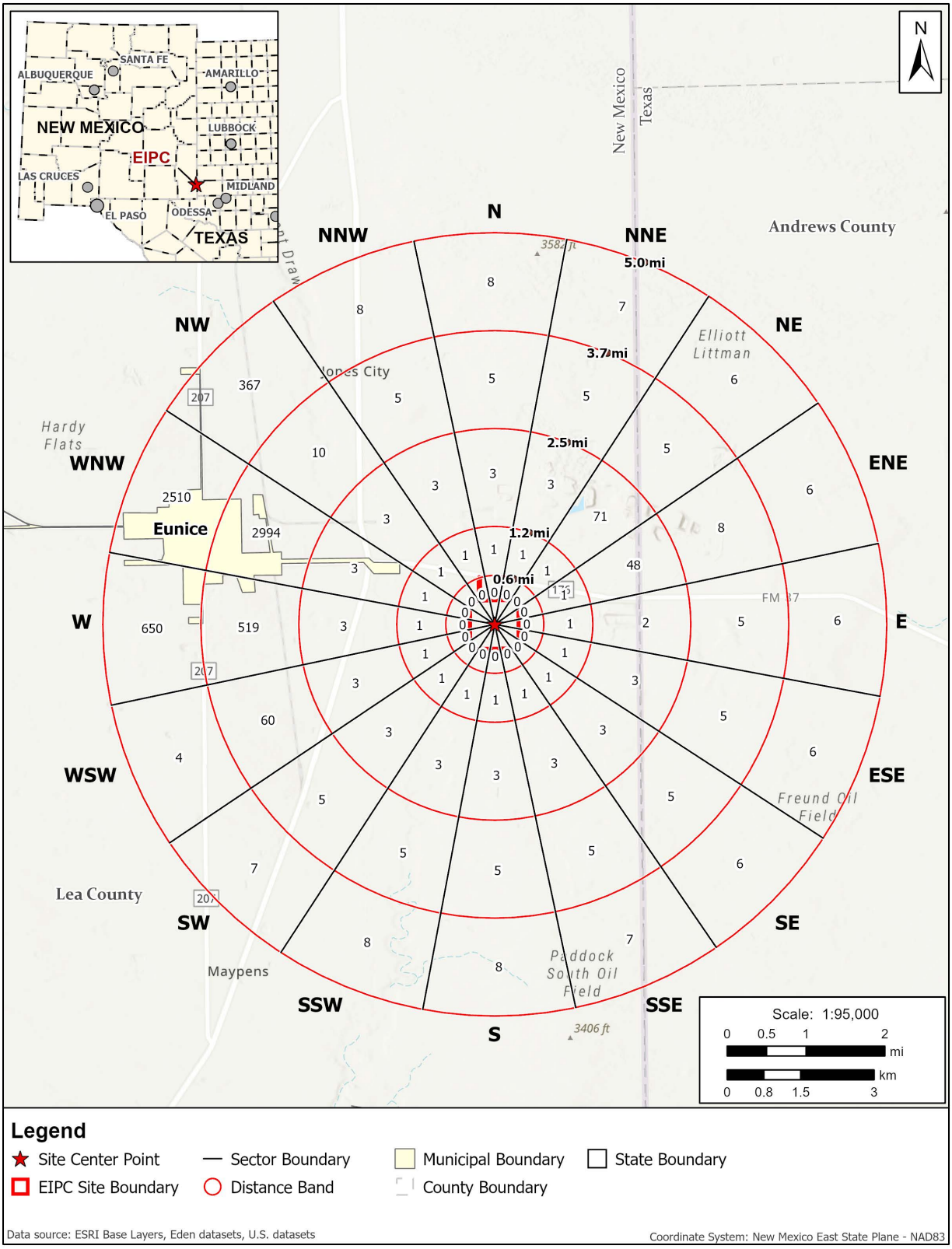
Combined Resident and Transient Population Distribution — 2029



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Combined Resident and Transient Population Distribution — 2030

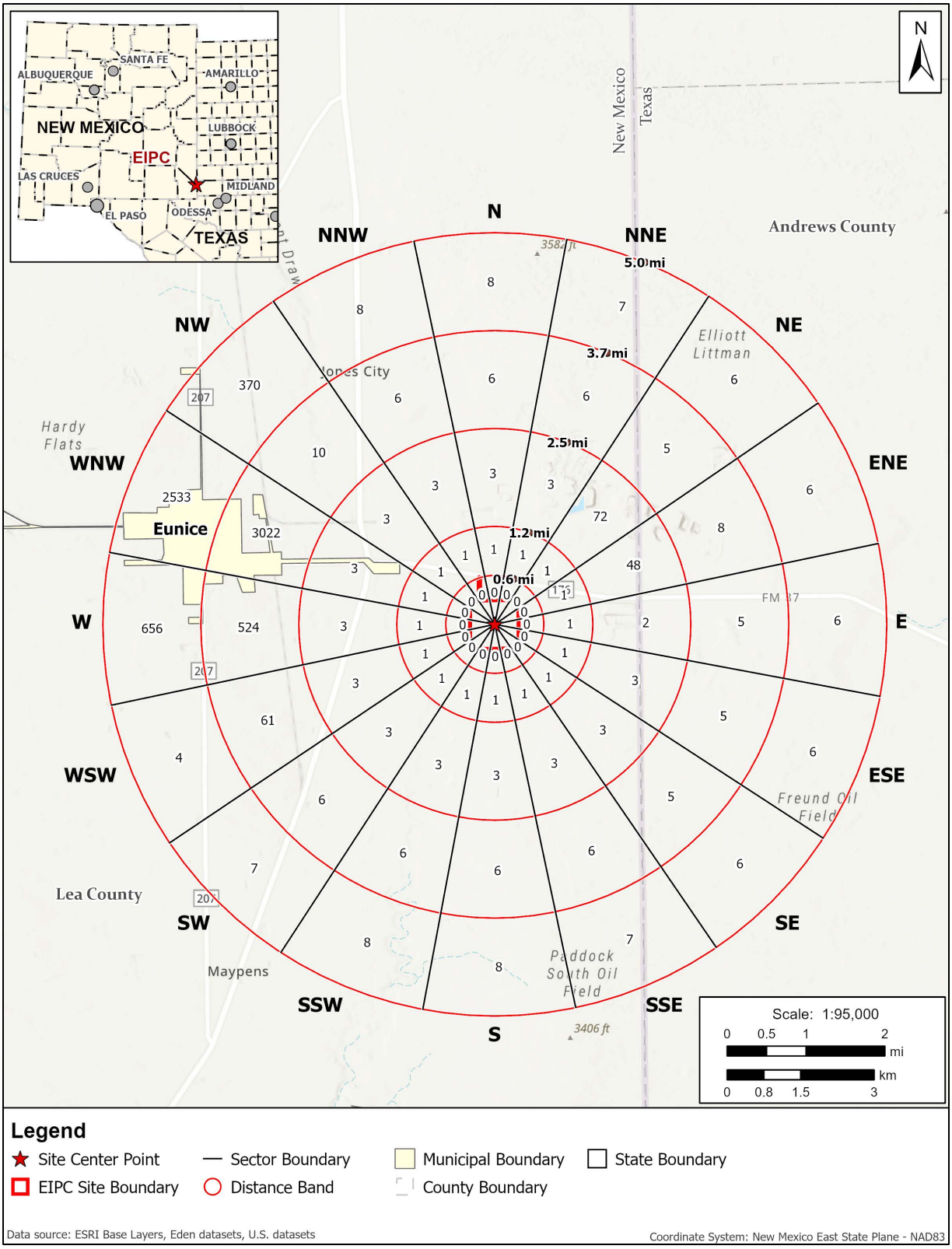

Figure 2.1-18
Combined Resident and Transient Population Distribution — 2040

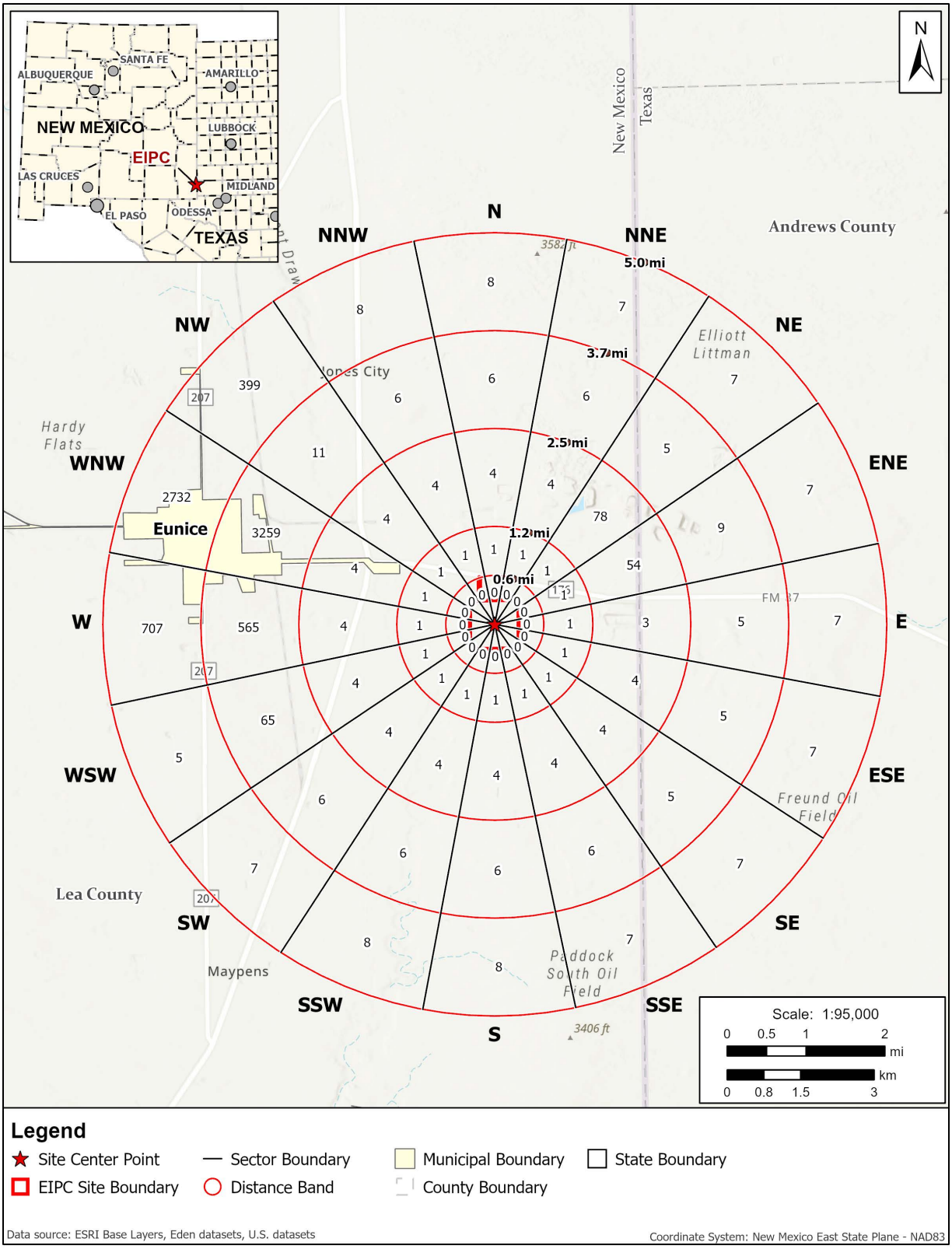

Figure 2.1-19
Combined Resident and Transient Population Distribution — 2050

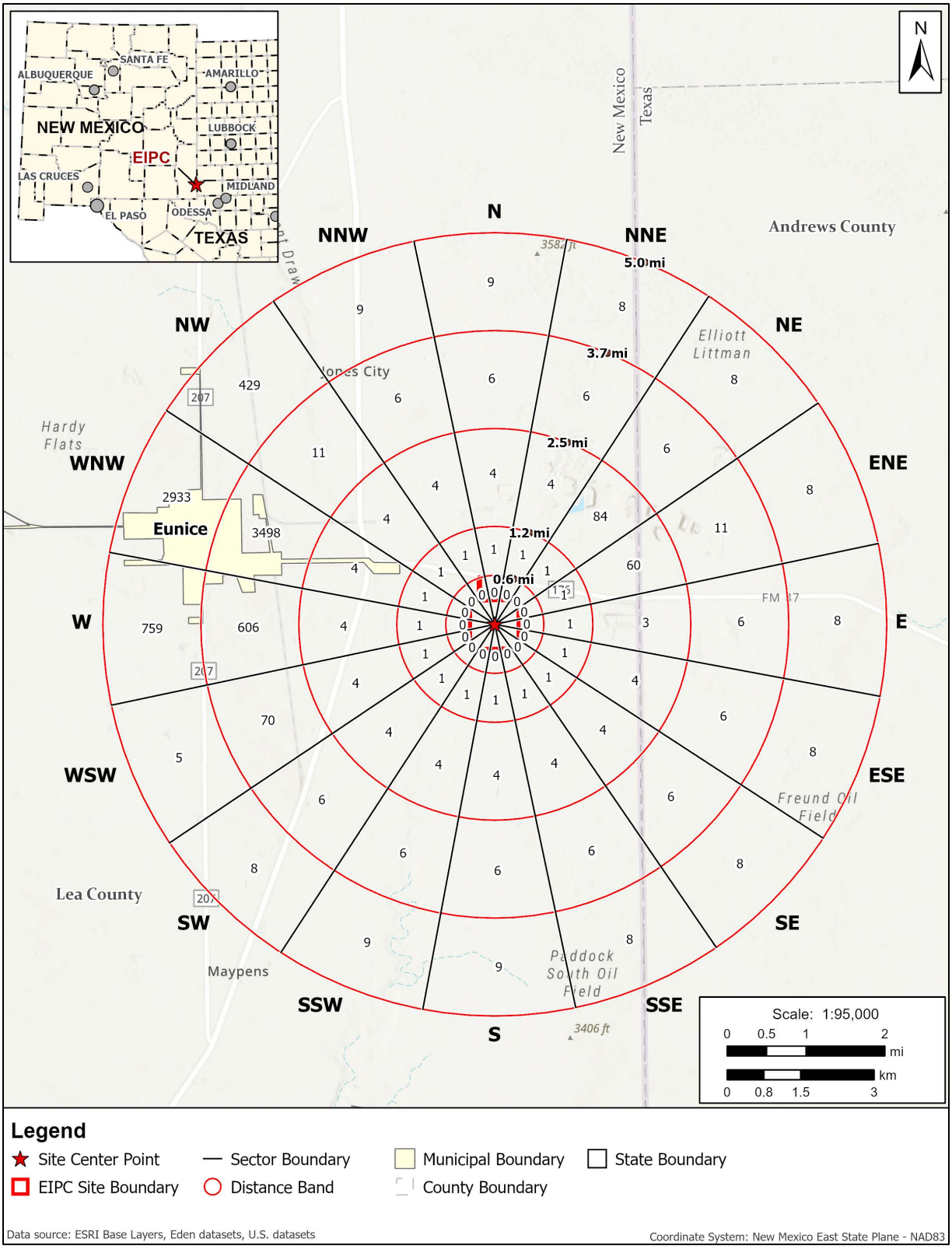

Figure 2.1-20
Combined Resident and Transient Population Distribution — 2060

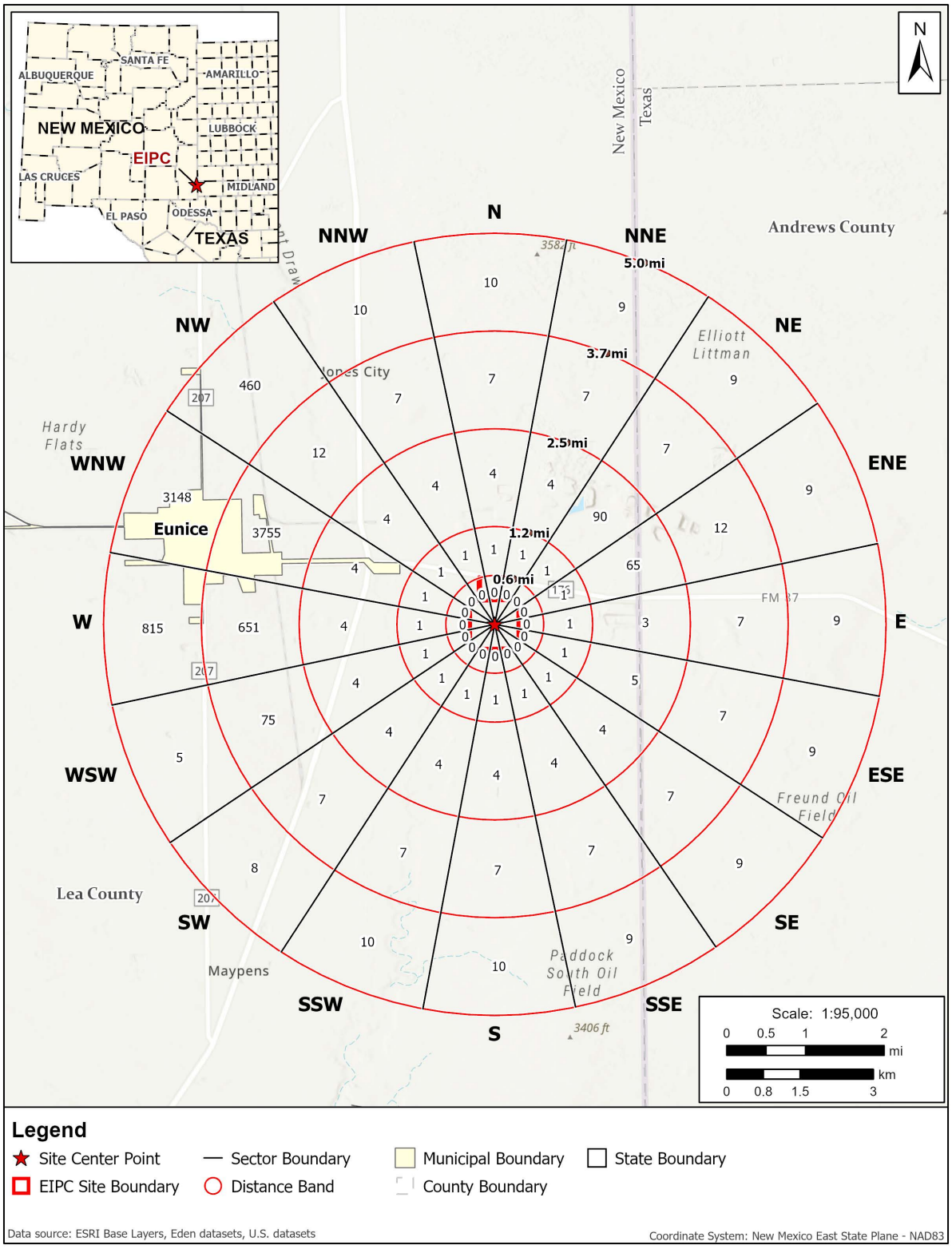

Figure 2.1-21
Combined Resident and Transient Population Distribution — 2070

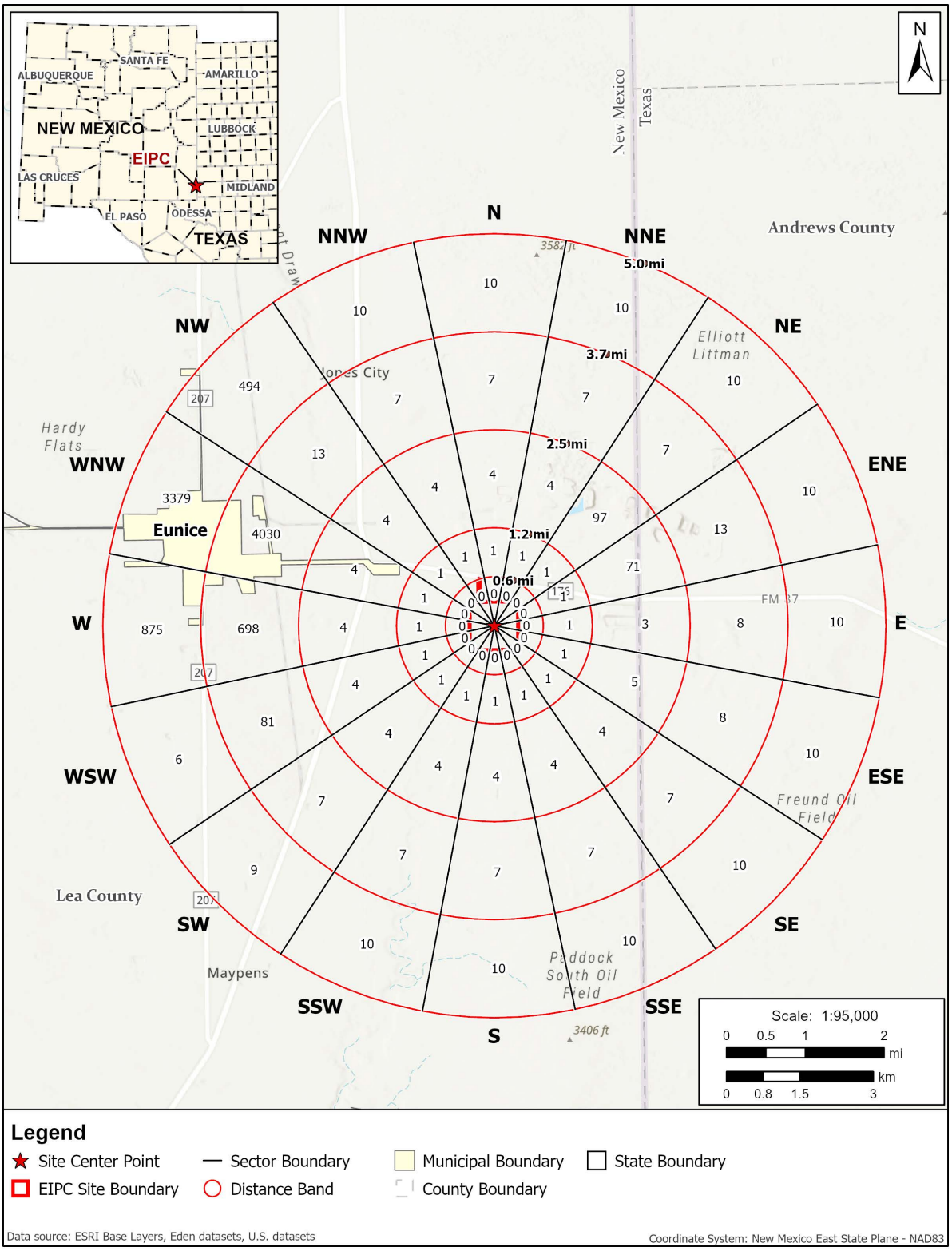

Figure 2.2-1
Facilities within 5 Miles of EIPC

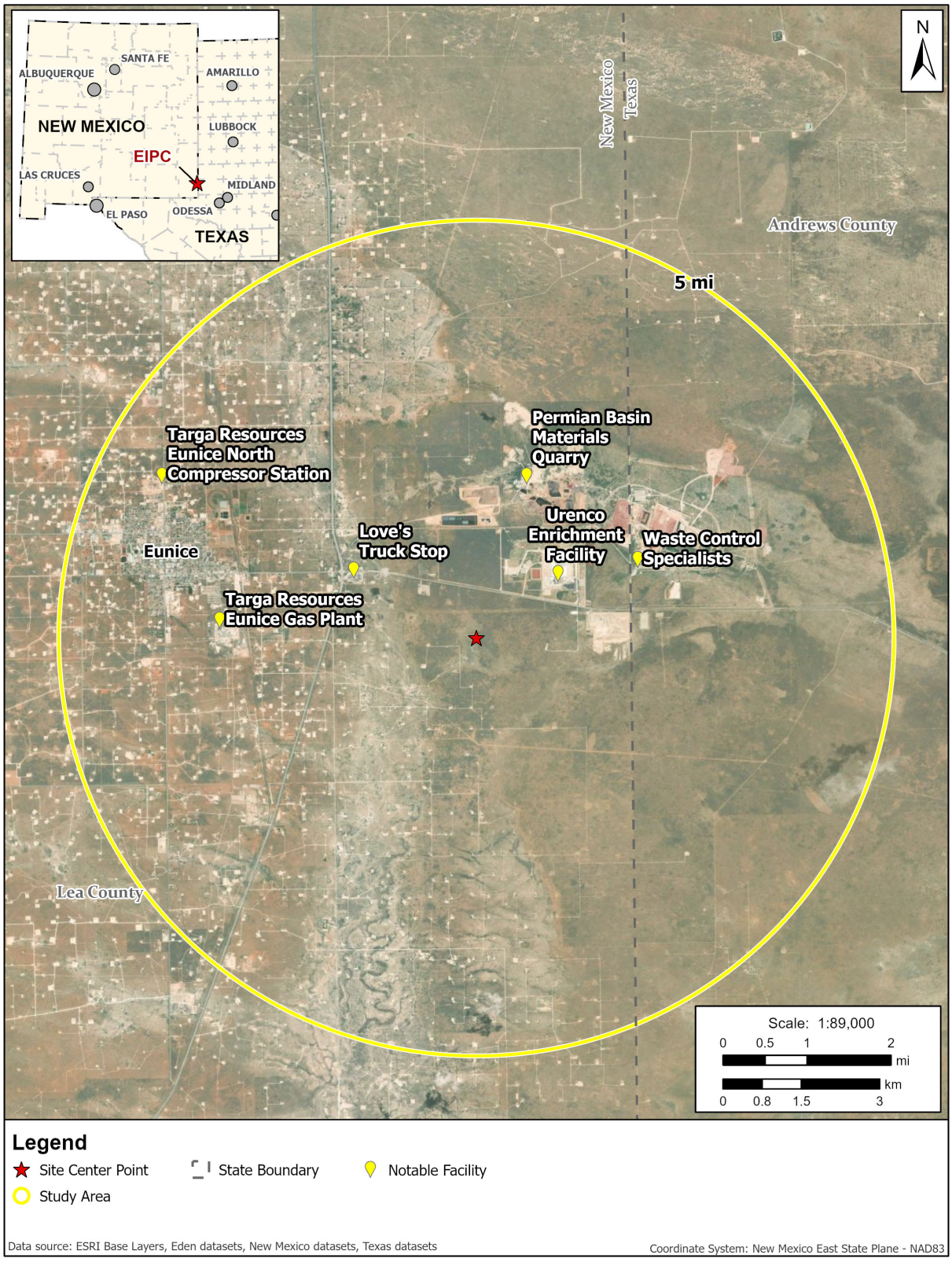

Figure 2.2-2
Railways and Roadways within 5 Miles of EIPC

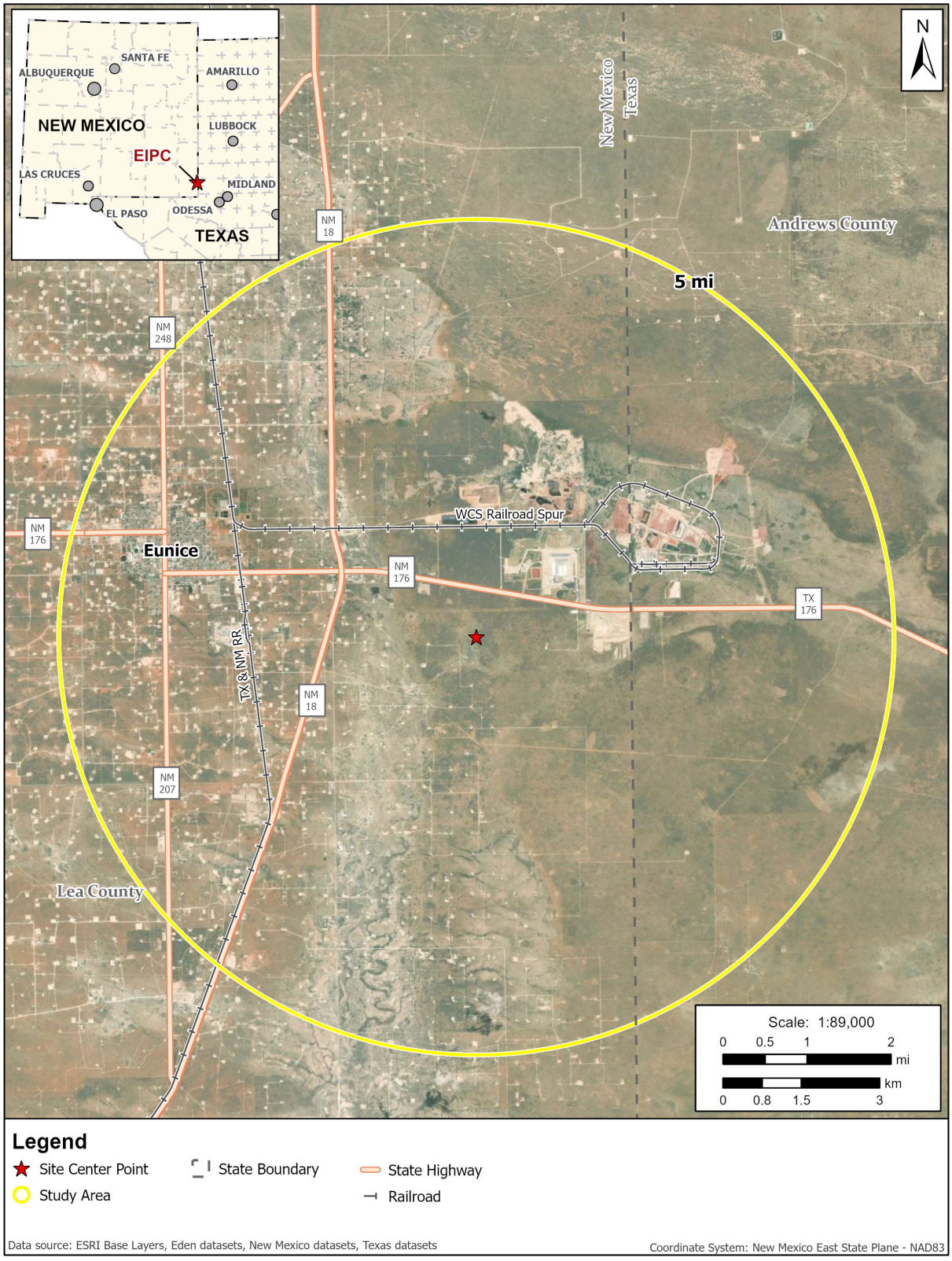

Figure 2.2-3
Gas and Oil Wells near EIPC

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Figure 2.2-4
Gas and Liquid Pipelines near EIPC

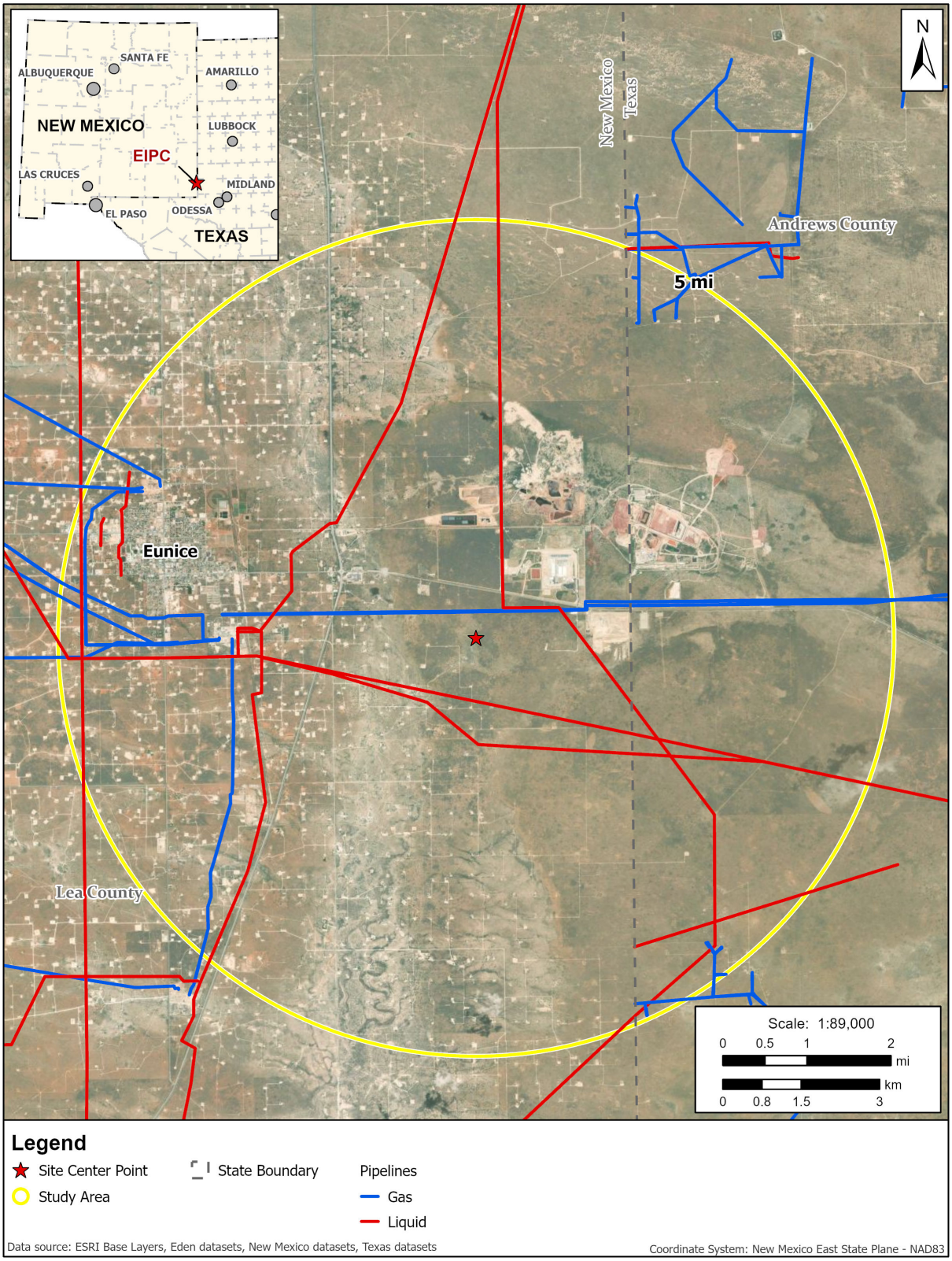


Figure 2.2-5
Flight Routes within 10 Miles of EIPC

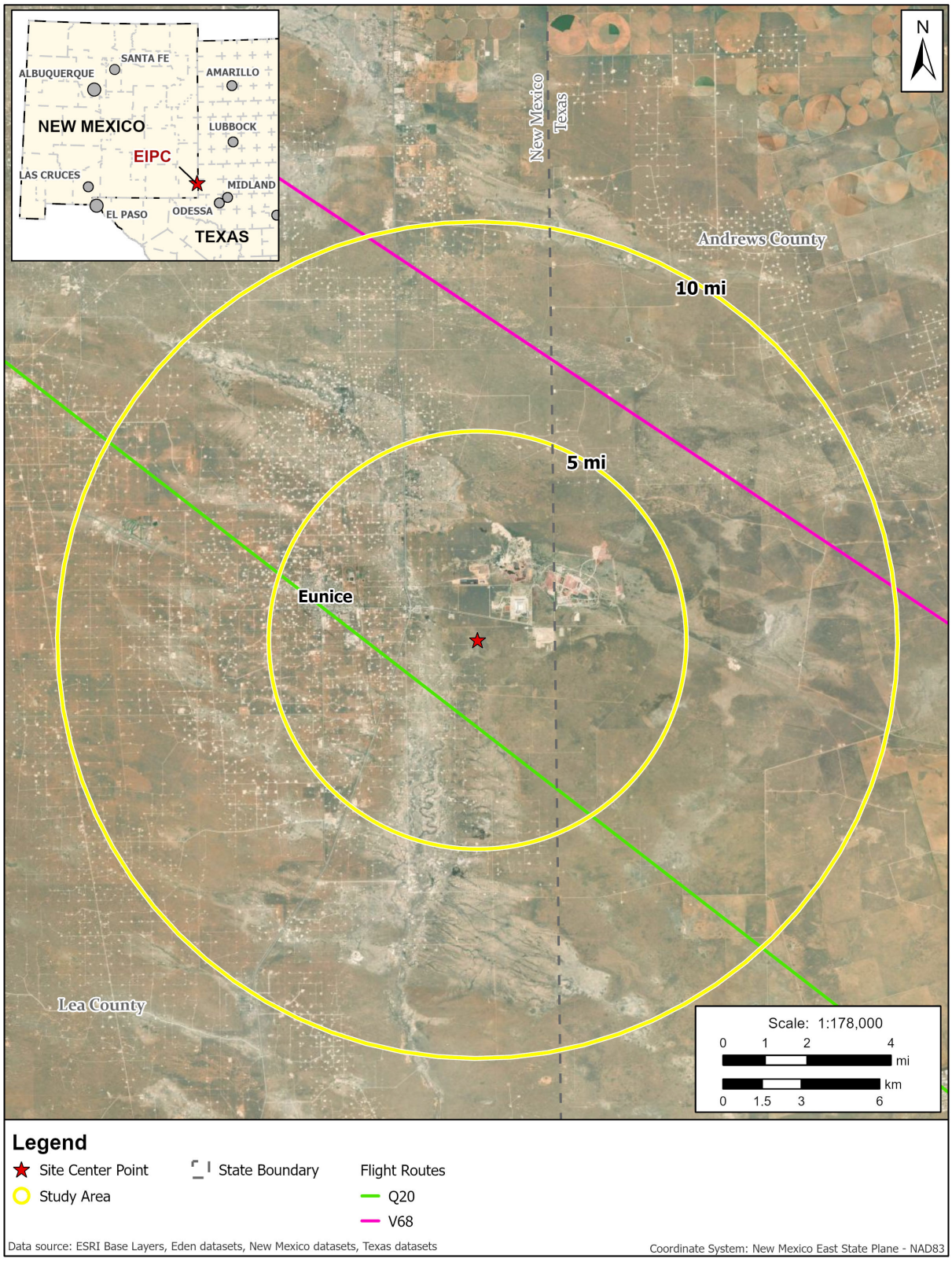
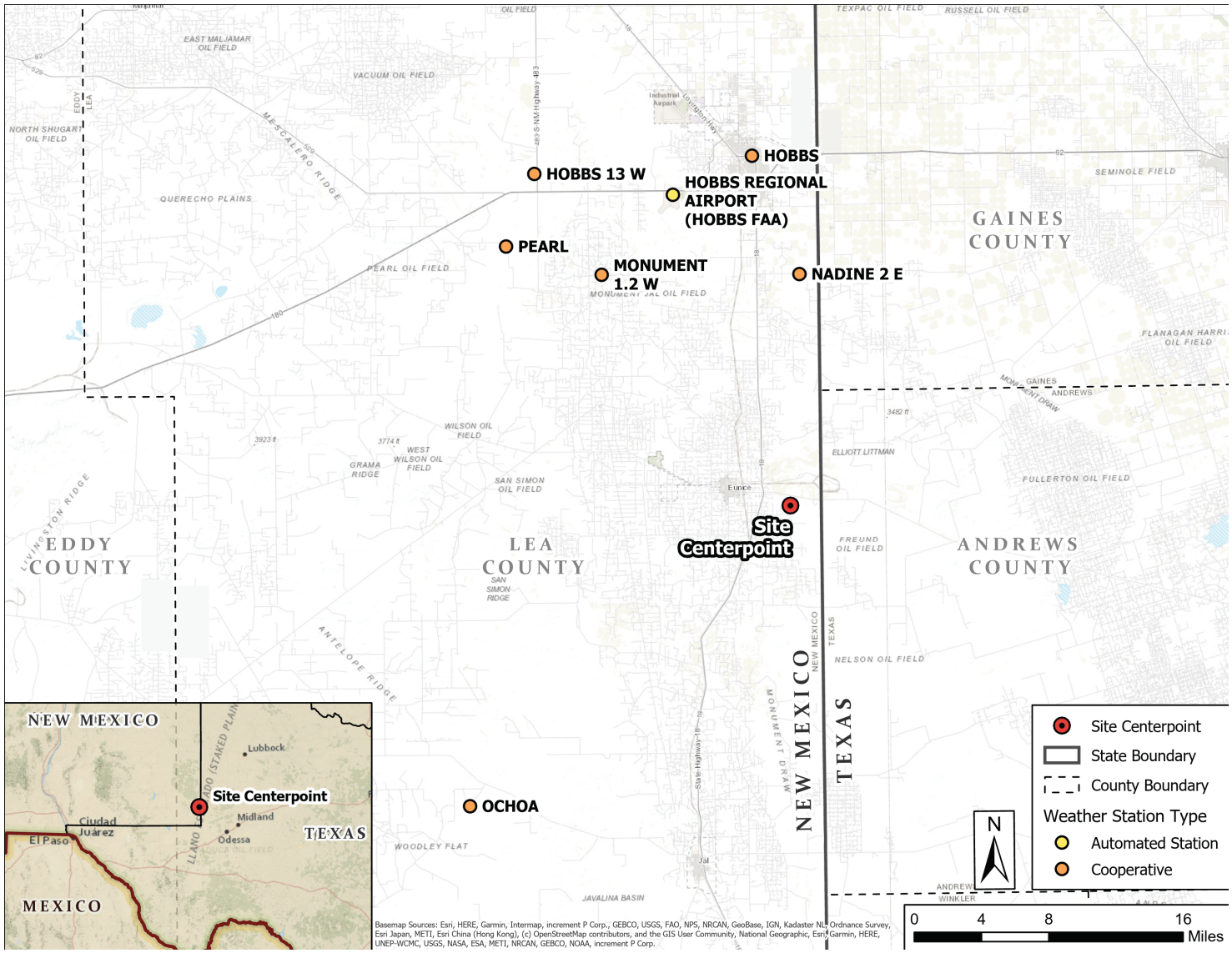
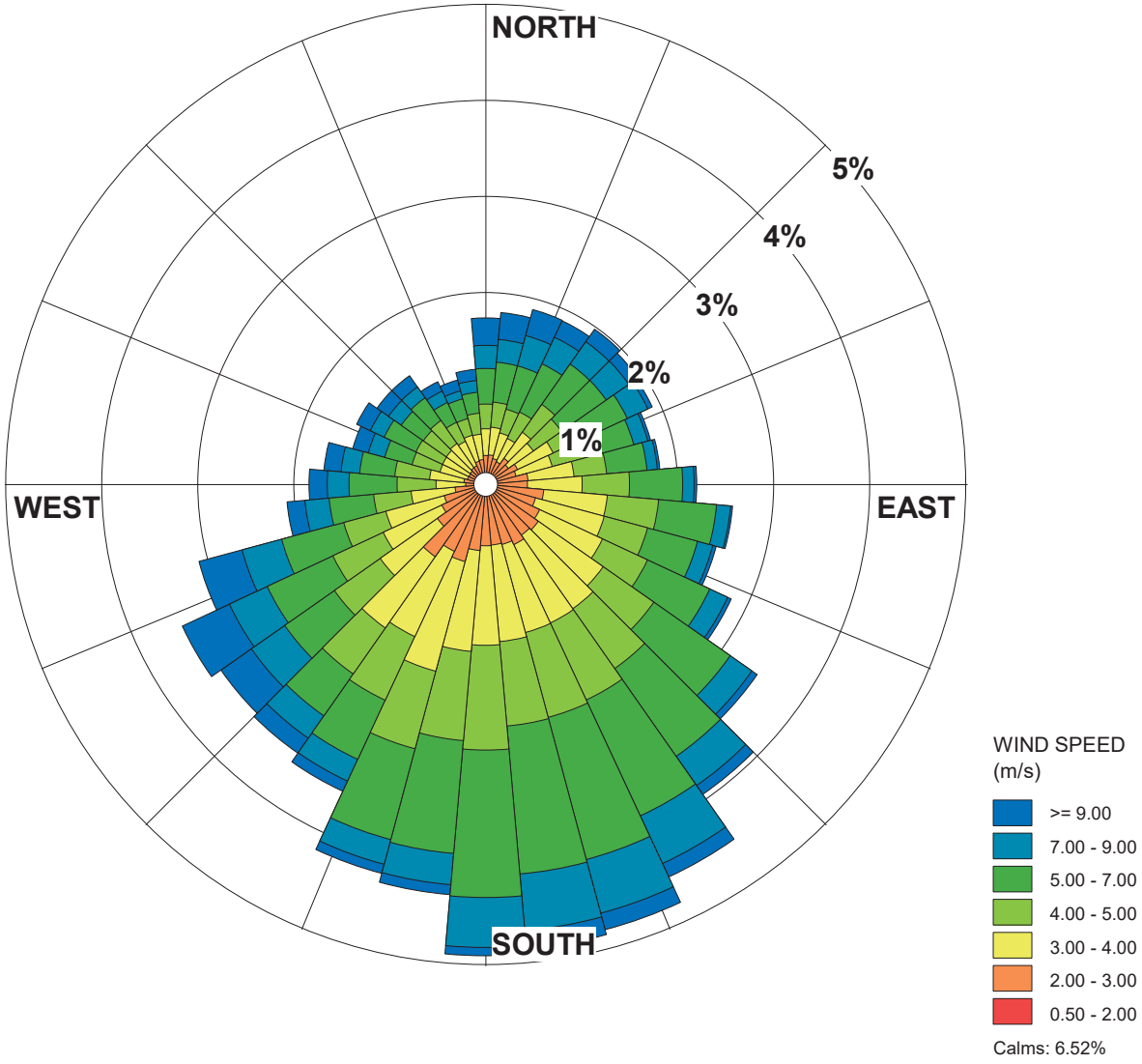


Figure 2.3-1
Map Identifying Local Meteorological Stations



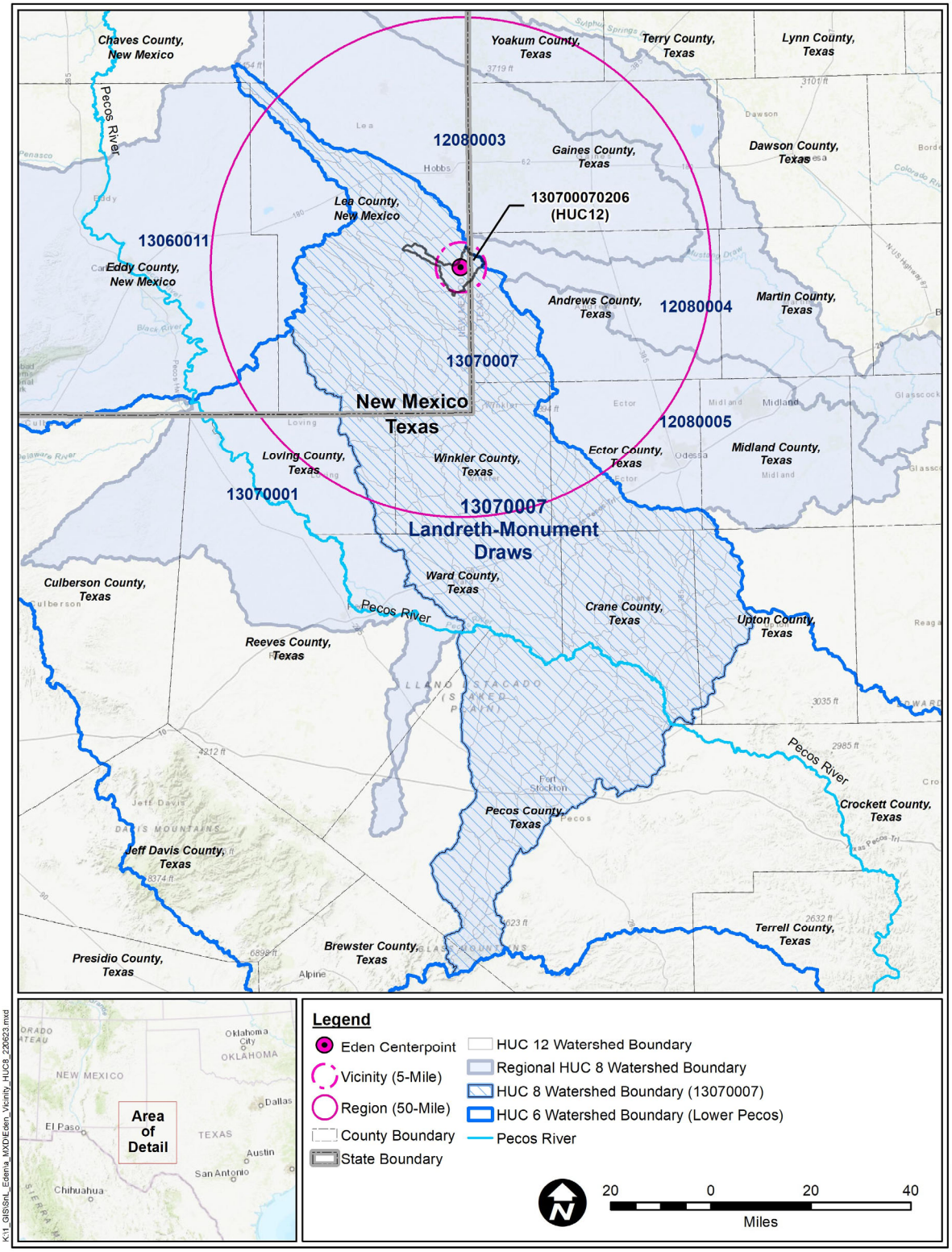
NWS, 2022.

Figure 2.3-2
Annual Wind Rose Lea County Regional Airport, New Mexico (2017 – 2021)



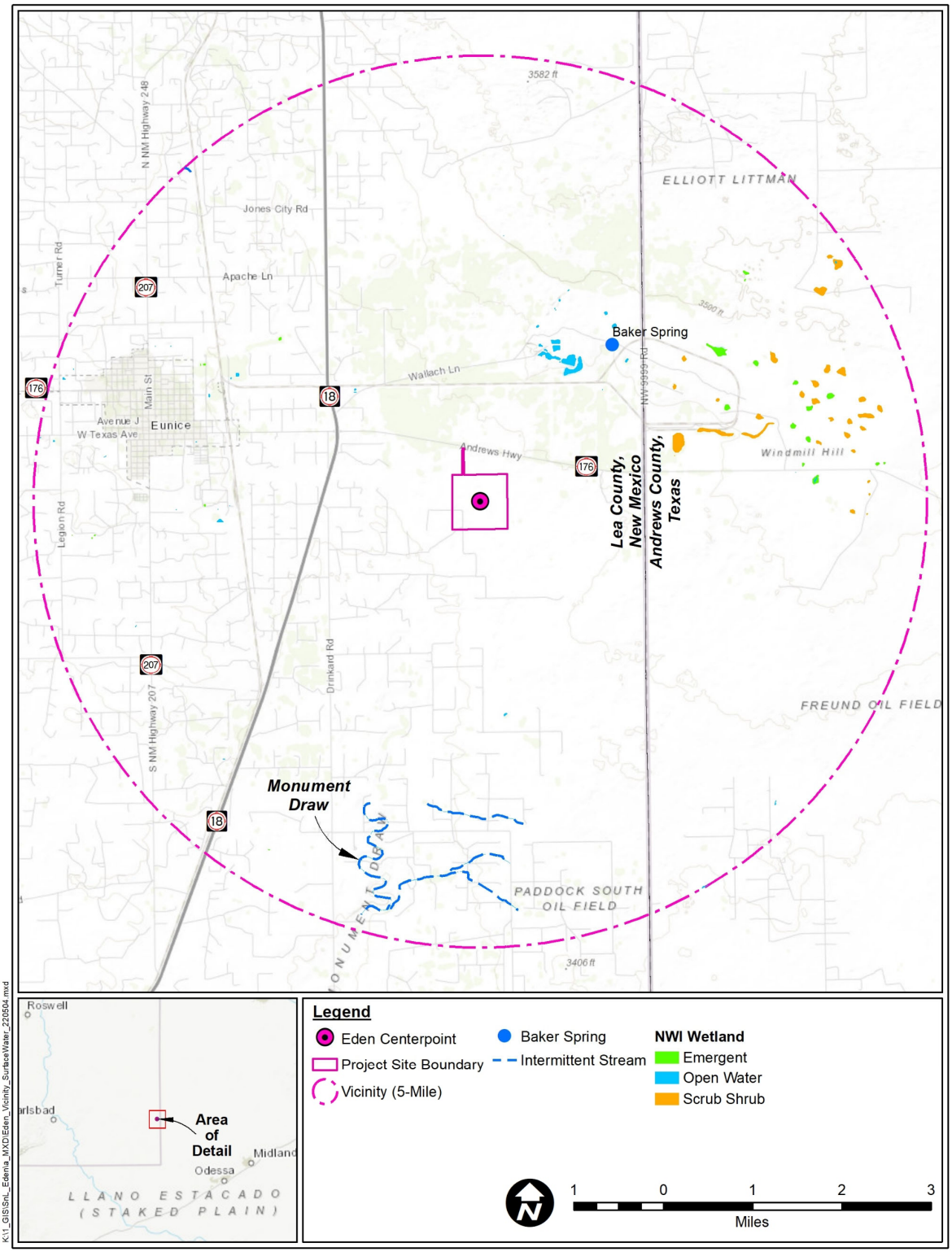
Source: NCEI, 2022e.

Figure 2.4-1
Landreth-Monument Draw Watershed Extent



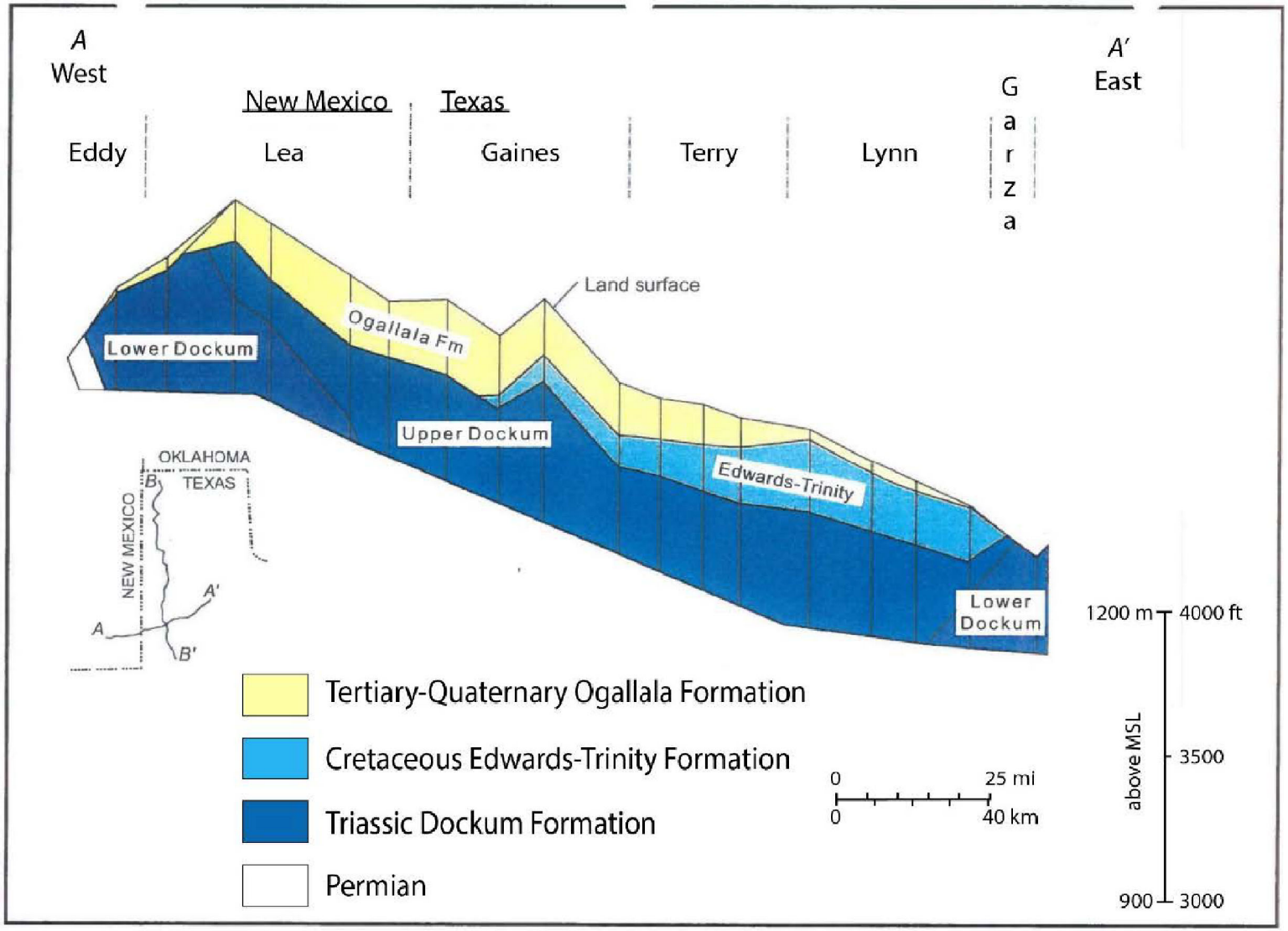
Source: USGS, 2022f.

Figure 2.4-2
Surface Water Features in the Vicinity of the Project Site



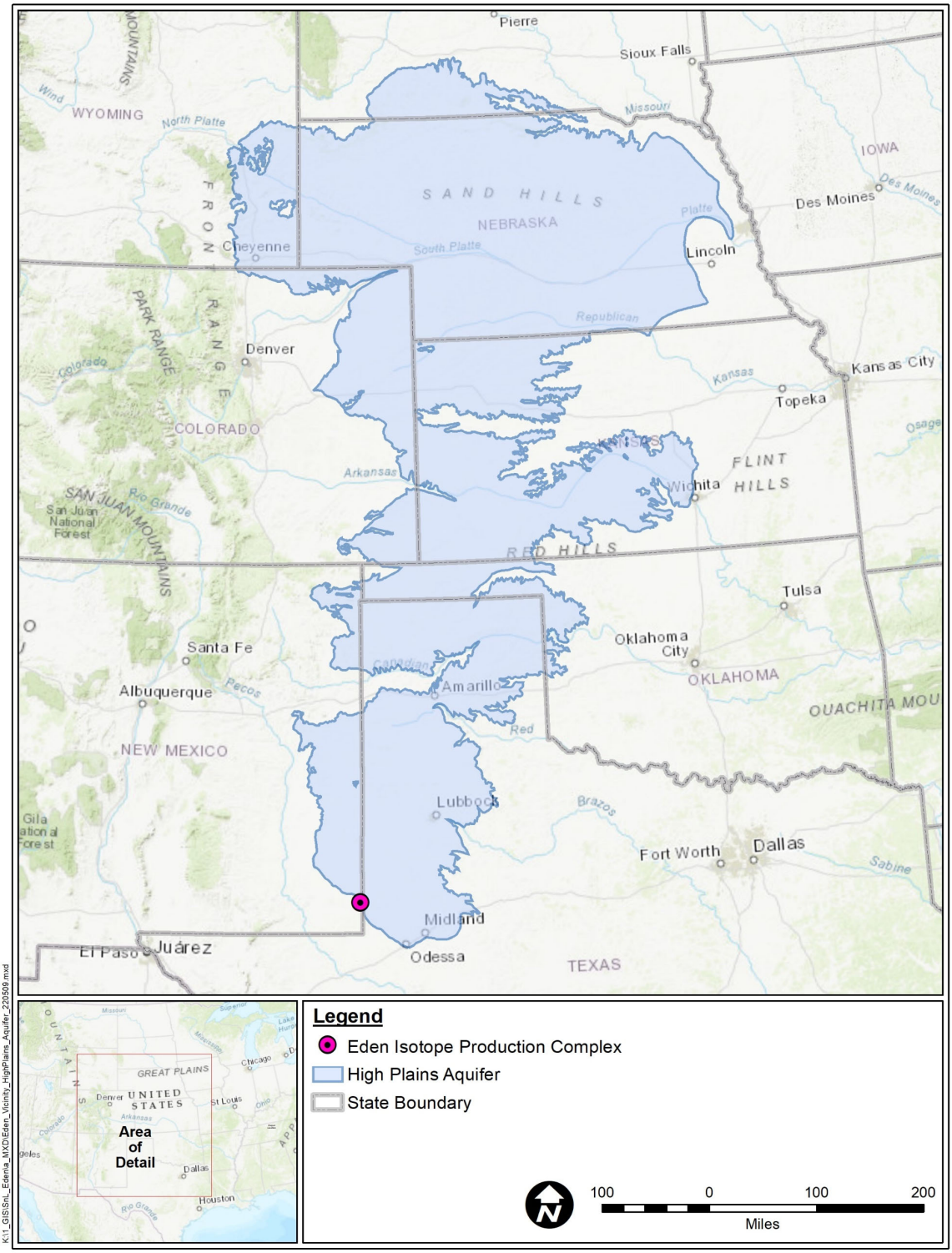
Source: USGS, 2016f.

Figure 2.4-3
West to East Hydrostratigraphic Cross-Section of West Texas and Southeastern New Mexico



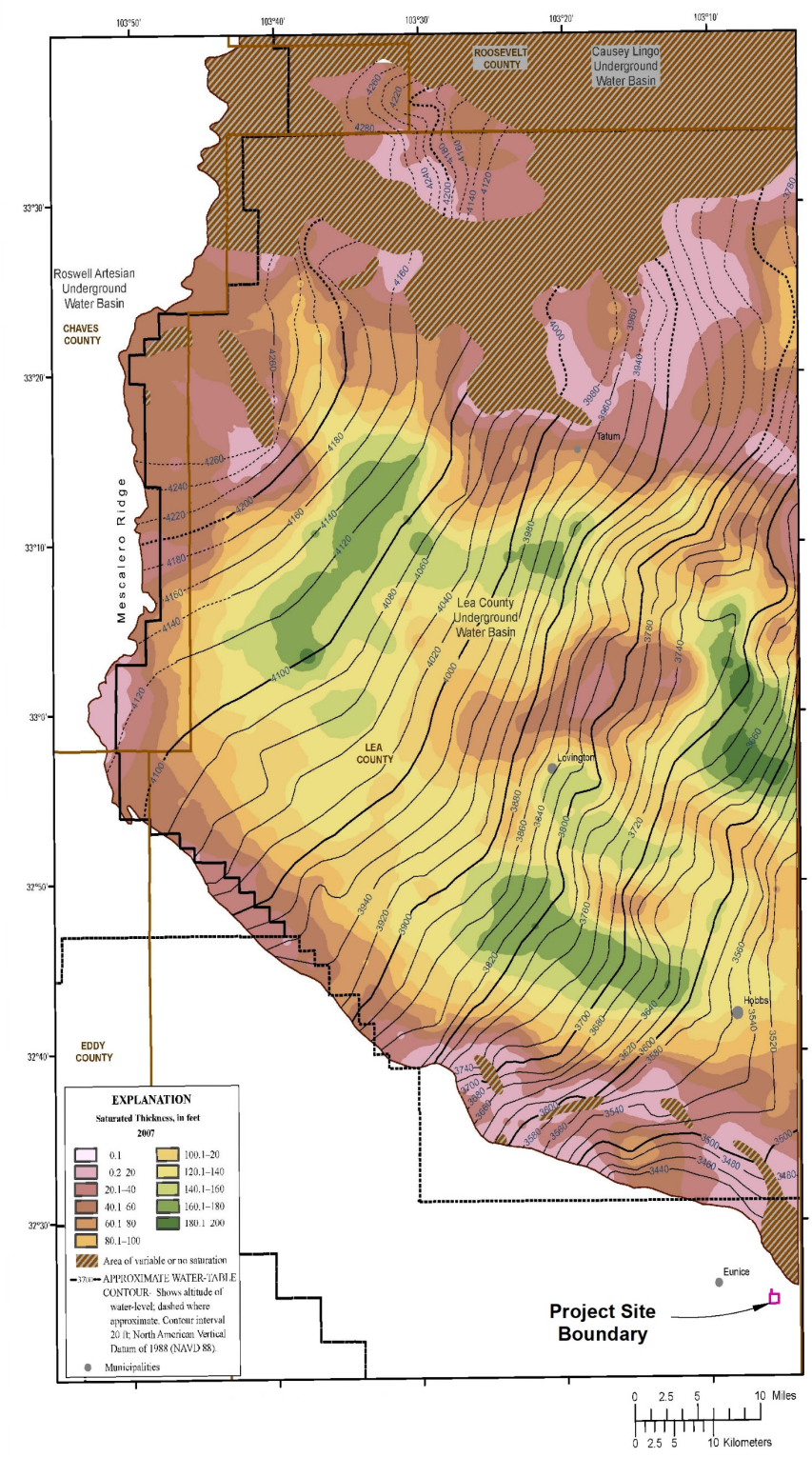
Source: NRC, 2020

Figure 2.4-4
High Plains (Ogallala) Aquifer



Source: USGS, 2016.

Figure 2.4-5
Water-Table Levels and Aquifer Saturated Thickness for the High Plains Aquifer in Lea County, New Mexico



Source: USGS, 2008.

Figure 2.4-6
USGS Monitoring Wells near the Project Site

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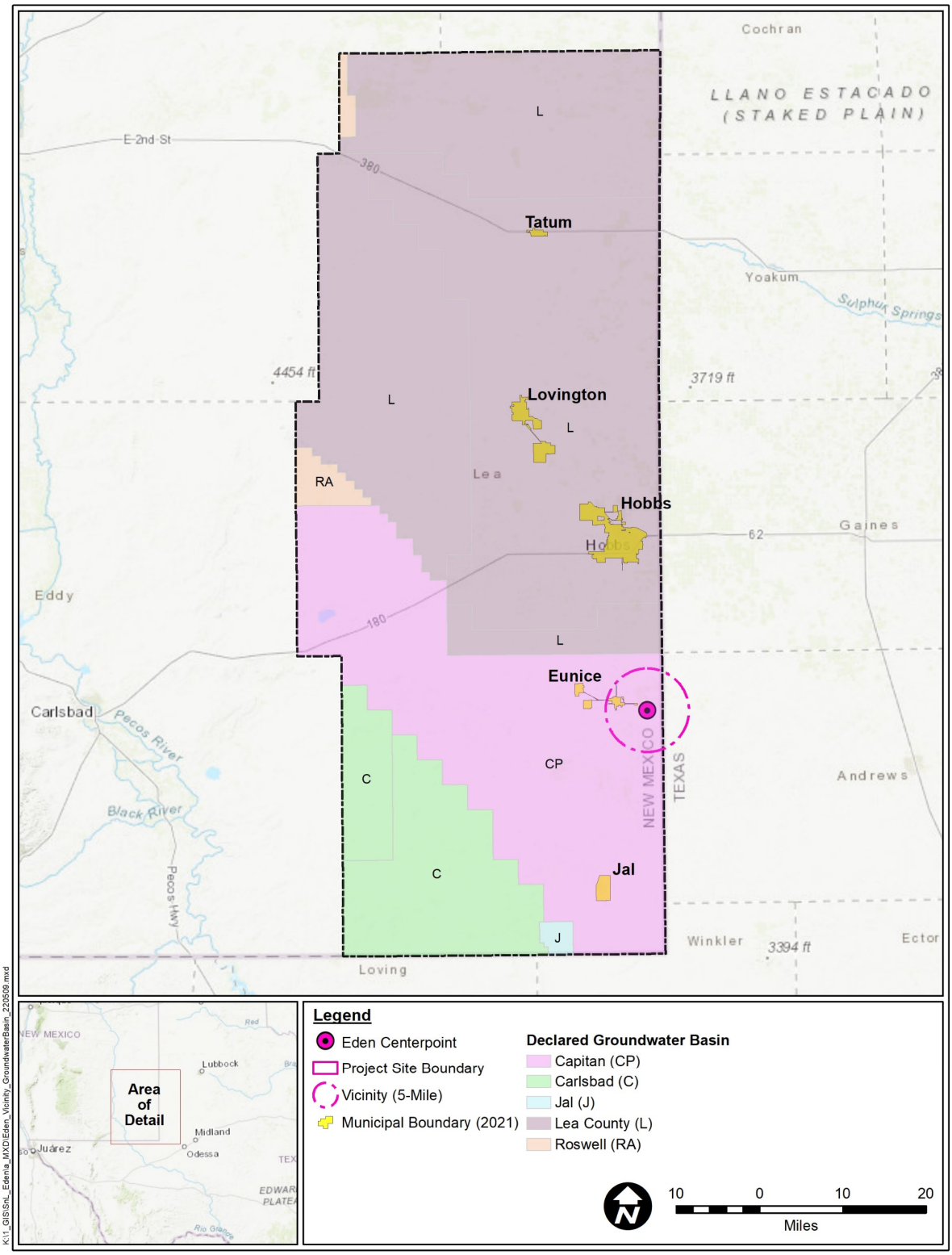
Source: USGS, 2016.

Figure 2.4-7
Underground Water Basins in Lea County, New Mexico



Source: NMOSE, 2020.

Figure 2.4-8
EIPC Building Layout

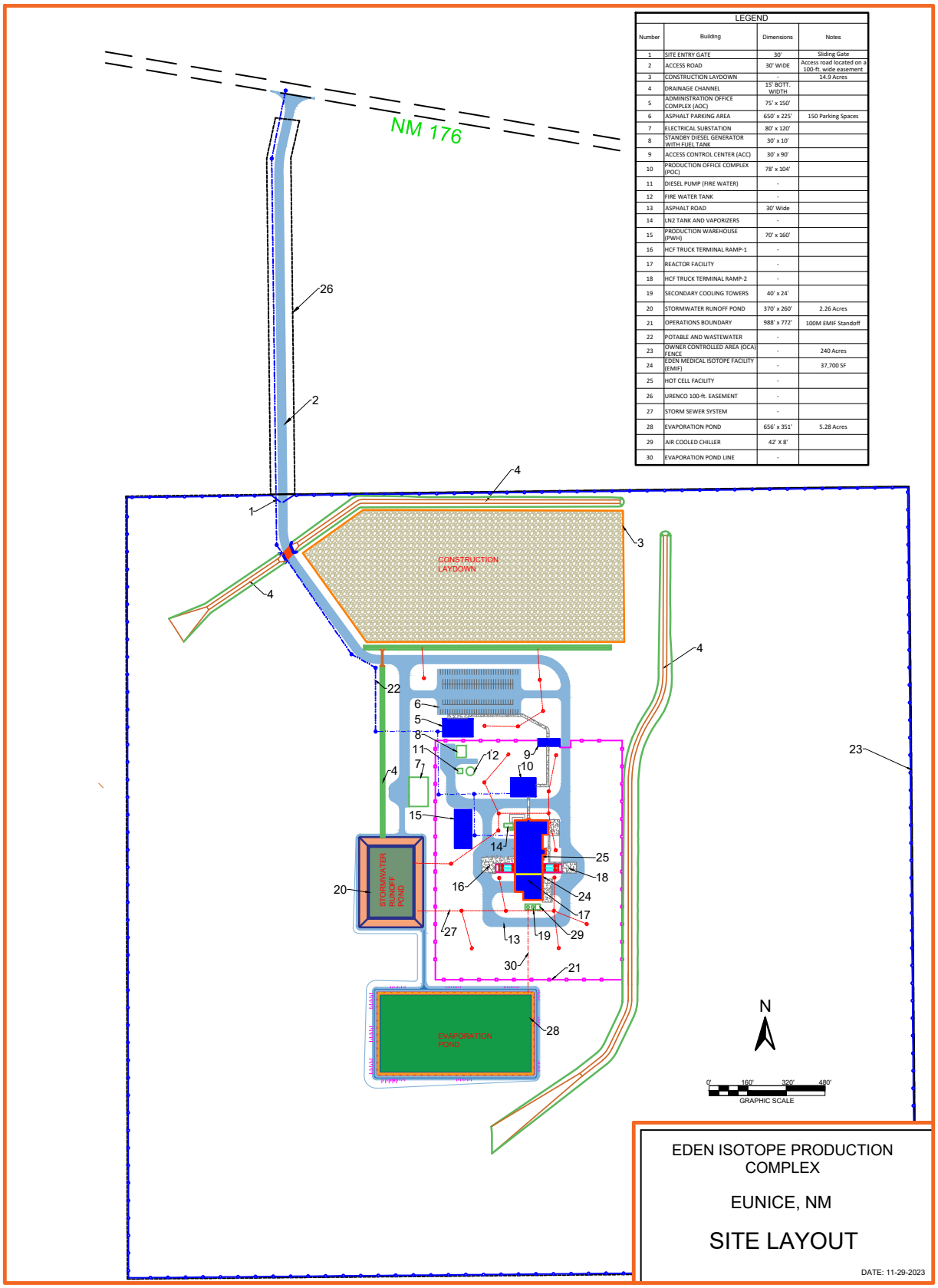
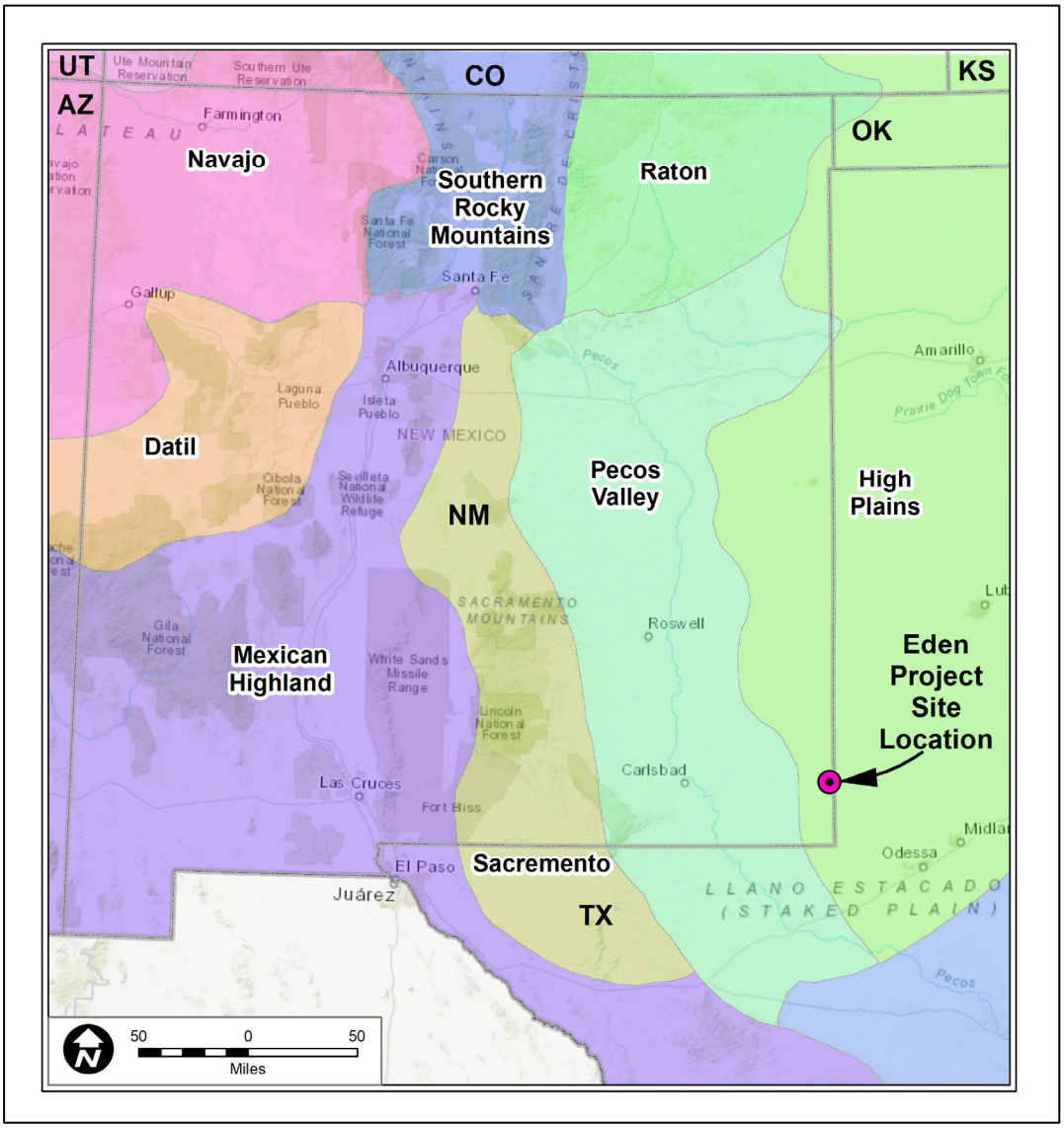
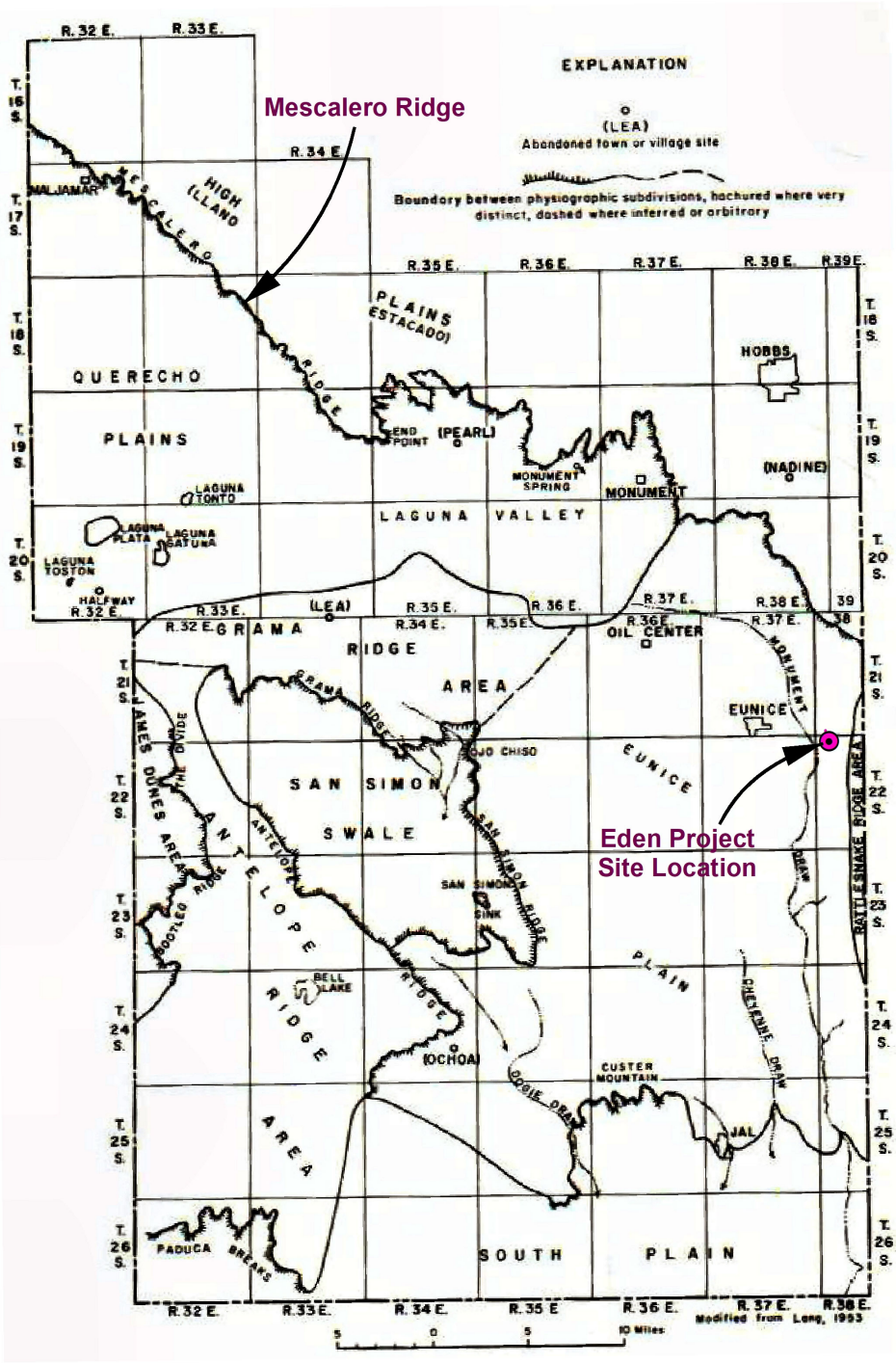


Figure 2.5-1
Regional Physiography



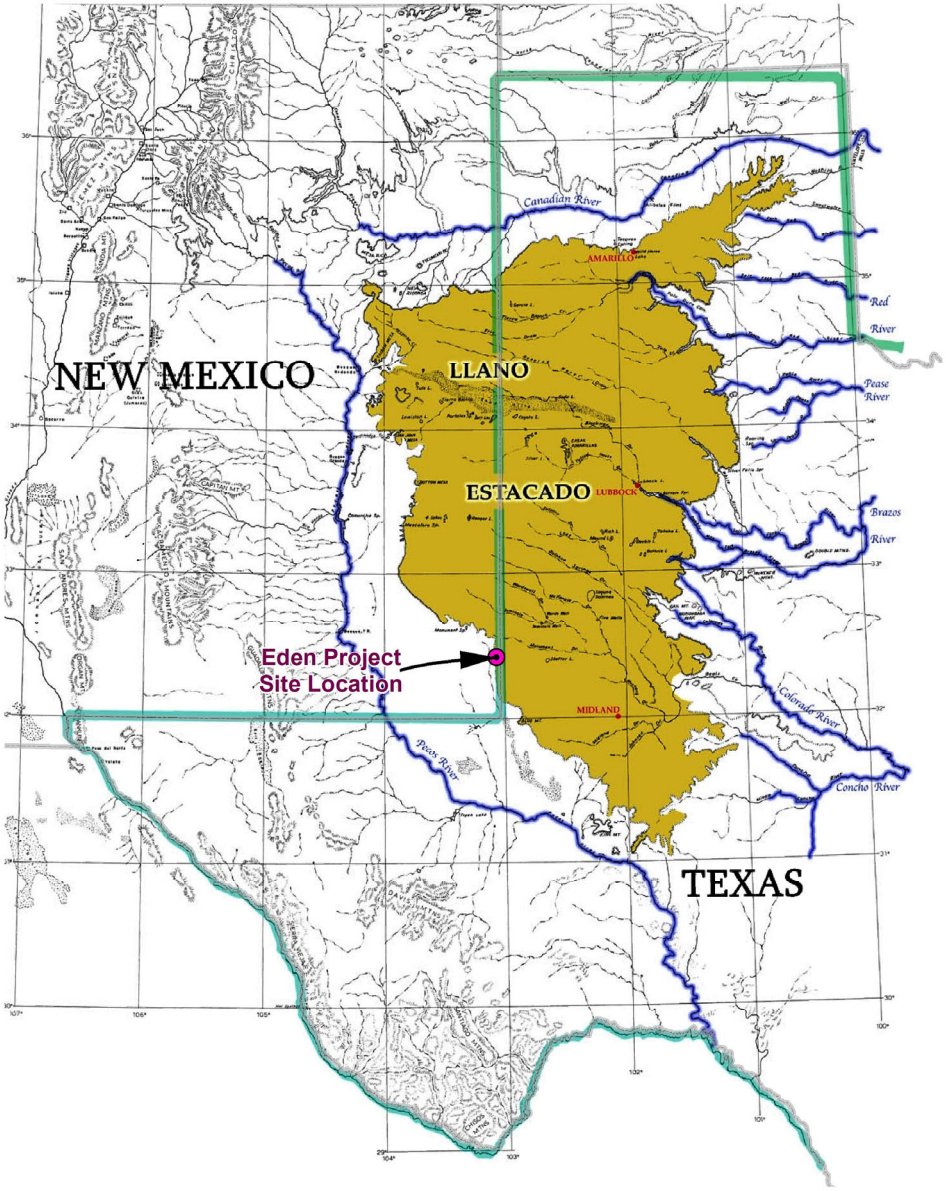
Source: AECOM, 2012.

Figure 2.5-2
Physiographic Subdivisions of Southern Lea County, New Mexico



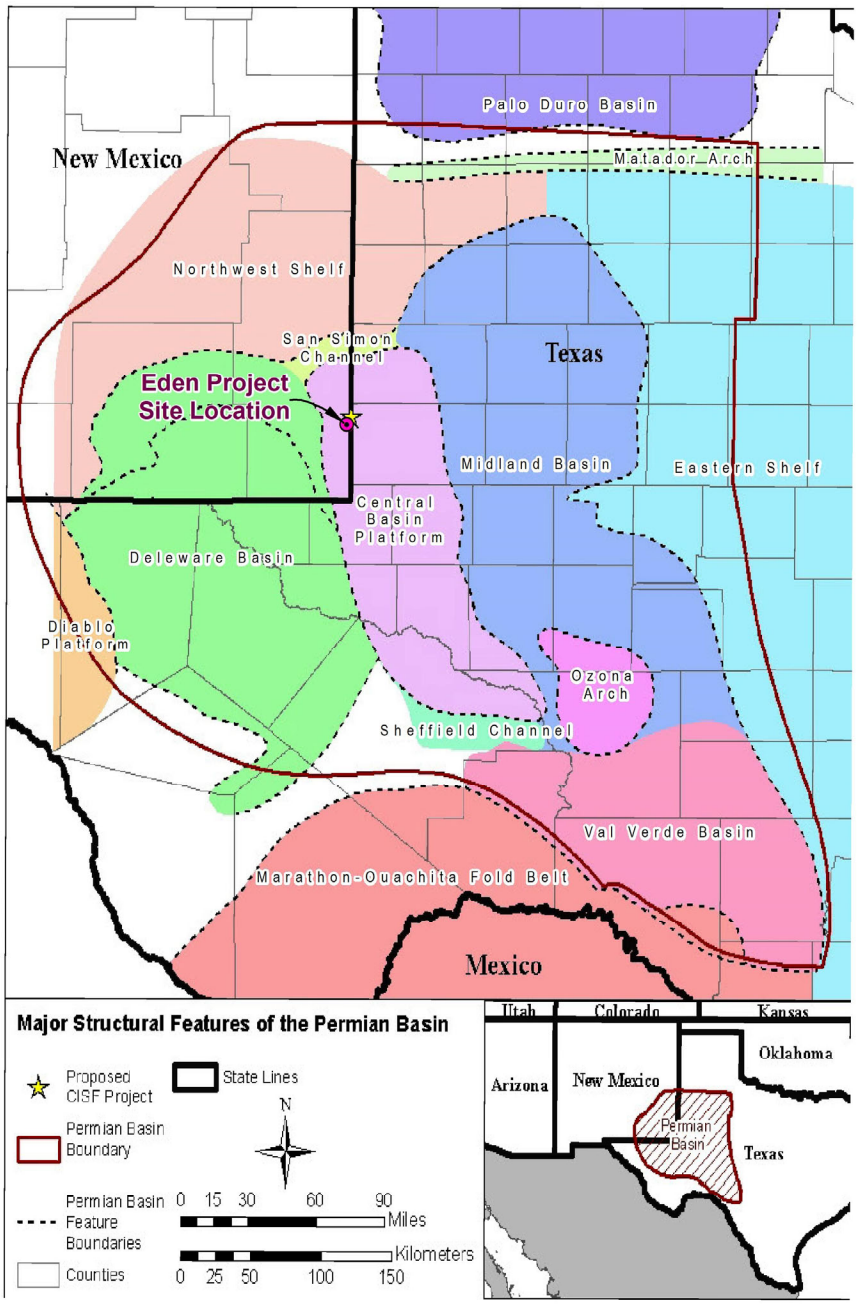
Source: Nicholson and Clebsch, 1961.

Figure 2.5-3
Llano Estacado and Vicinity



Source: IIFP, 2009.

Figure 2.5-4
Major Structural Features of the Permian Basin of West Texas and Southeastern New Mexico



Source: NUREG-2239

Figure 2.5-5
Stratigraphic Column for Central Basin Platform

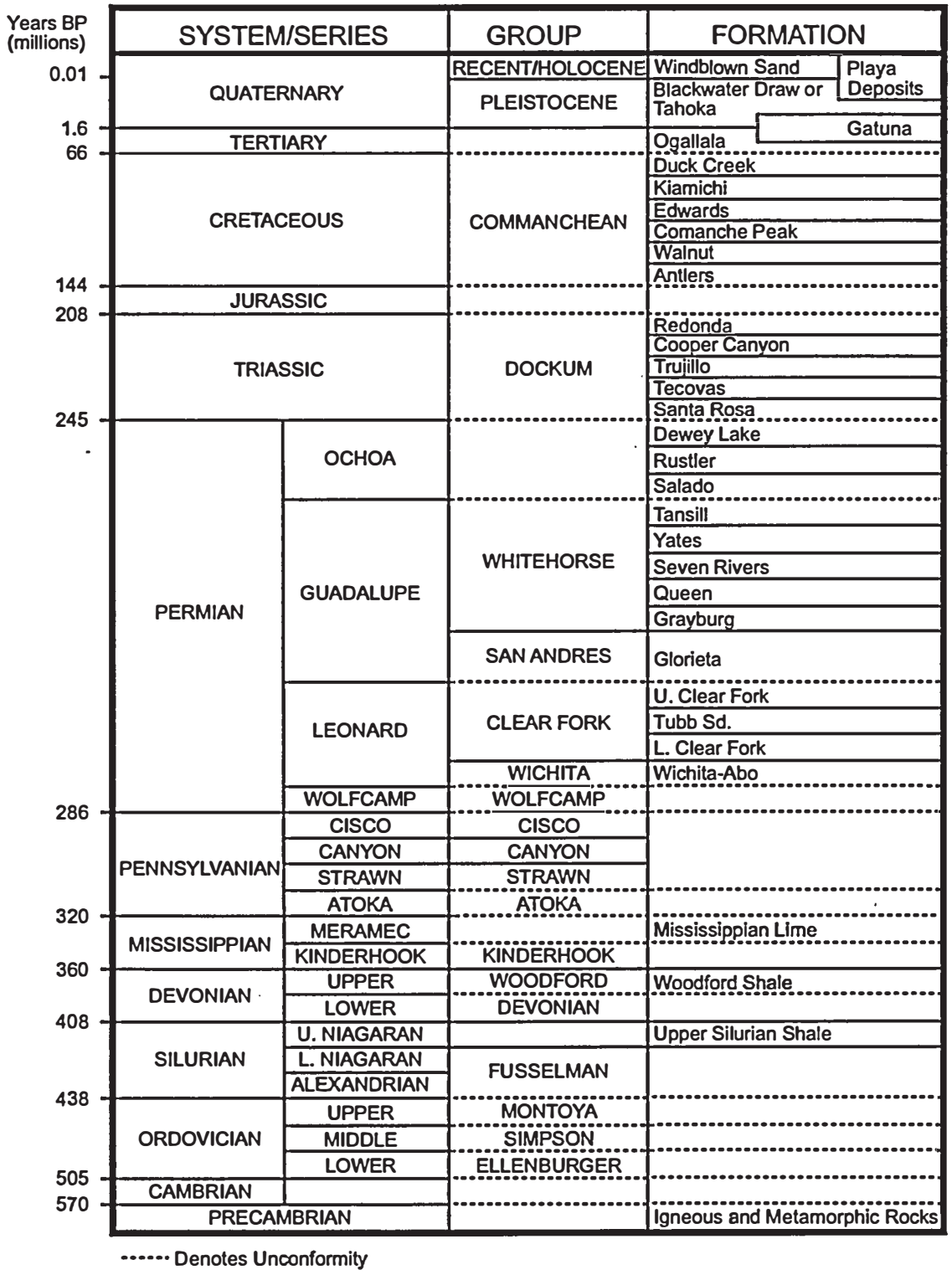
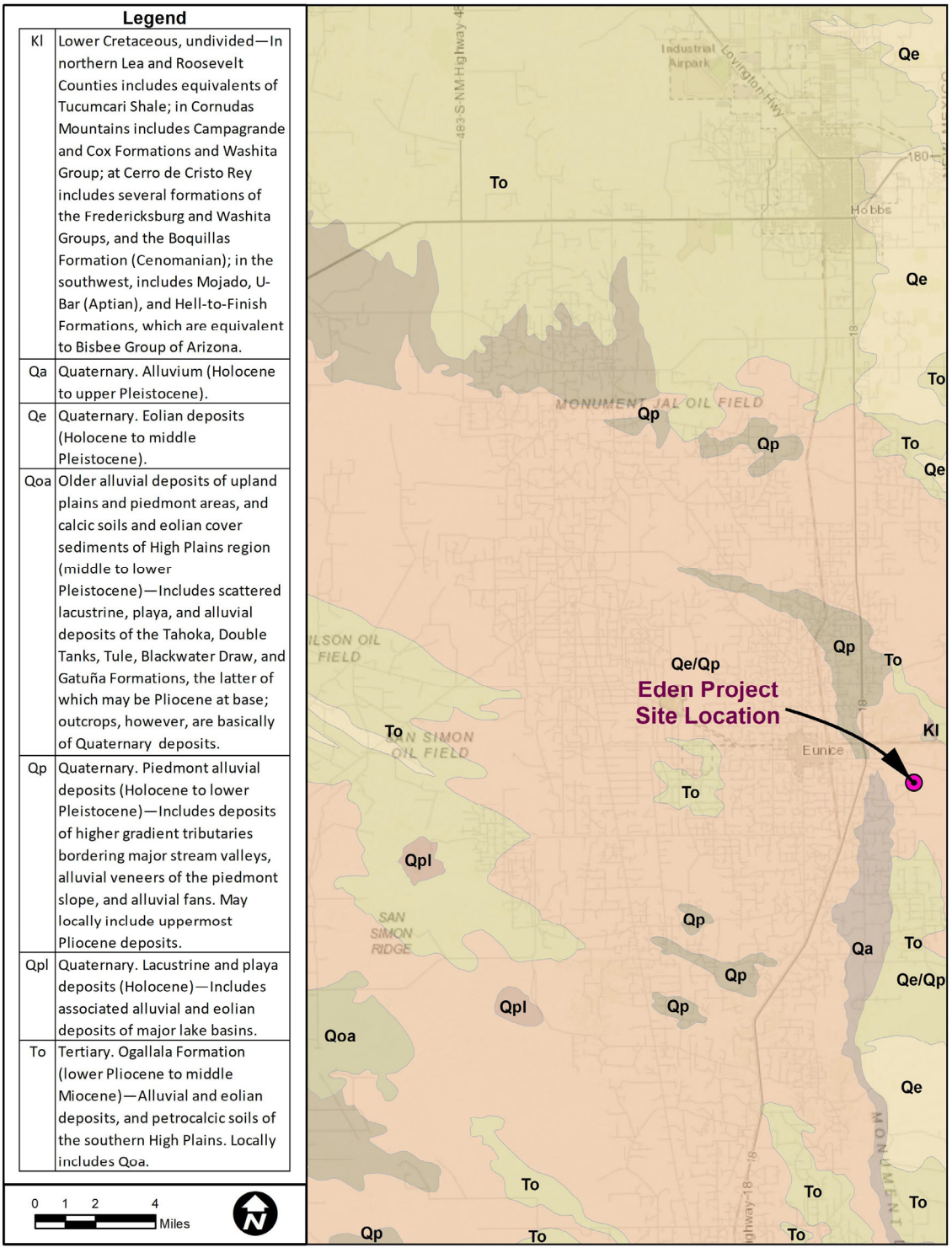


Figure 2.5-6
New Mexico Geologic Map of the Project Region



Source: New Mexico Bureau of Geology and Mineral Resources, 2003.

Figure 2.5-7
Oil and Gas Wells in the Vicinity of the Site

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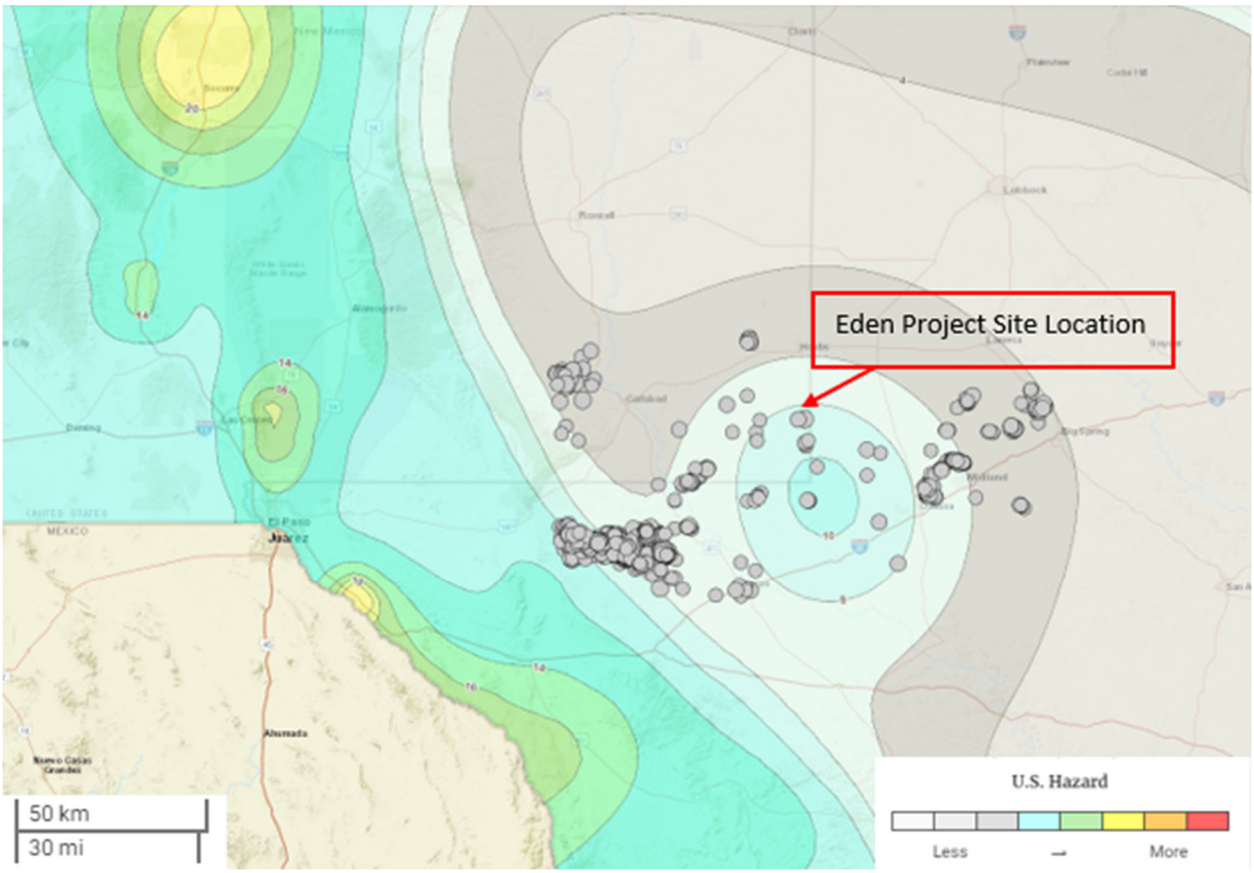
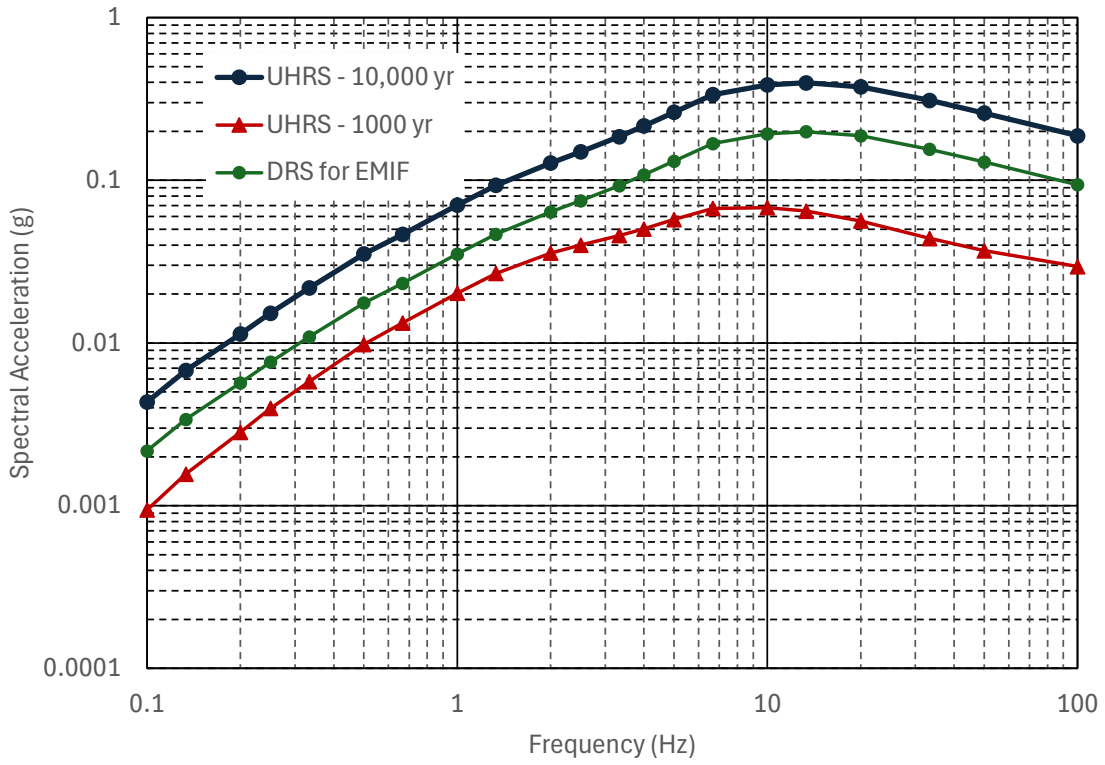
Figure 2.5-8
Recorded Seismic Events from 1950 to 2022 in the Region



Source: USGS, 2022b.

Figure 2.5-9
Uniform Hazard and Design Response Spectra at Surface Elevation



Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 3
Design of Systems, Structures, and Components

eden | Precision Science. Human Impact.

CHAPTER 3
DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AGS	American Glovebox Society
ANS	American Nuclear Society
ANSI	American National Standards Institute
APC	atmospheric pressure change
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
BE	best estimate
CFR	Code of Federal Regulations
CQC	Complete Quadratic Combination
DBE	design basis earthquake
DOE	U.S. Department of Energy
DOF	degrees of freedom
DRS	design response spectrum
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
g	standard acceleration due to gravity
ft.	feet
ft^2	square feet

Acronym/Abbreviation	Definition
HCF	Hot Cell Facility
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ICC	International Code Council
IEEE	Institute of Electrical and Electronics Engineers
in.	inch(s)
ISG	Interim Staff Guidance
ISRS	in-structure response spectra
kph	kilometer(s) per hour
lb.	pound(s)
LB	lower bound
LECS	liquid effluent control system
LEU	low-enriched uranium
LS	Limit State
m	meter(s)
MCER	maximum considered earthquake
MFRS	main force resisting system
Mo-99	molybdenum-99
mph	miles per hour
MRI	Mean Recurrence Interval
MWFRS	main wind force resisting system
NEI	Nuclear Energy Institute
NFPA	National Fire Protection Association
NM	New Mexico
NRC	U.S. Nuclear Regulatory Commission

Acronym/Abbreviation	Definition
PSAR	Preliminary Safety Analysis Report
QAPD	Quality Assurance Program Description
QL	Quality Level
RF	Reactor Facility
RRS	required response spectrum
SAR	Safety Analysis Report
SCB	steel confinement box(es)
SDB	seismic design basis
SDC	seismic design category
SEI	Structural Engineering Institute
SRSS	square root of the sum of squares
SSC	structure(s), system(s), and component(s)
SSI	soil-structure interaction
TEDE	total effective dose equivalent
UB	upper bound
URENCO	Urenco, USA
U.S.	United States
ZPA	zero period acceleration

3 DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

This chapter identifies and describes the principal architectural and engineering design criteria for the structures, systems, and components (SSCs) that are required to ensure facility safety and protection of the staff, the public and the environment at the Eden Isotope Production Complex (EIPC). As described in Chapter 1, the EIPC consists of the following structures:

- Administration Office Complex.
- Access Control Center.
- Production Office Complex.
- Production Warehouse.
- Eden Medical Isotope Facility (EMIF).

The EMIF houses the 1.8-megawatt non-power reactor located within the Reactor Facility (RF) and the radioisotope production Hot Cell Facility (HCF). The RF portion of the EMIF operates independently from the HCF. The commonality between the facilities is the transfer canal, a wall separating the facilities, and common utilities. The information presented in this chapter describes the safety-related functions and related design features of the EMIF that provide defense-in-depth against the uncontrolled release of radioactive material to the environment. The bases for the design criteria for the major systems are discussed in this chapter as well as in other chapters that are appropriately cross-referenced elsewhere in the Preliminary Safety Analysis Report (PSAR).

The EMIF and system design are based on defense-in-depth practices. Defense-in-depth practices refers to a design philosophy, applied from the outset and through completion of the design, that is based on providing successive levels of protection such that health and safety are not wholly dependent upon any single element of the design, construction, maintenance, or operation of the facility. Engineered controls are preferred over administrative controls in the EMIF defense-in-depth design. The net effect of incorporating defense-in-depth practices is a conservatively designed facility and system that exhibit a high level of tolerance to internal failures and external challenges. The risk insights obtained through performance of accident analysis can then be used to supplement the final design by focusing attention on the prevention and mitigation of higher risk potential accidents.

3.1 DESIGN CRITERIA

This section describes the design criteria applied to the EMIF SSCs. The design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for SSCs.

This application to the United States (U.S.) Nuclear Regulatory Commission (NRC) seeks to obtain a Construction Permit and subsequent Operating License for a utilization and production facility under Title 10 of the Code of Federal Regulations (CFR) Part 50 (10 CFR Part 50), Domestic Licensing of Production and Utilization Facilities. Occurring within the 10 CFR Part 50 licensed facility are several activities subject to 10 CFR Part 70, Domestic Licensing of Special Nuclear Material and management of byproduct material under 10 CFR Part 30, Rules of General Applicability to Domestic Licensing of Byproduct Material.

This license application is informed by the guidance in NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content, and Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors.

The operation of the EMIF is primarily focused on the irradiation of low-enriched uranium (LEU) metal foil targets within the RF, followed by the disassembly of the targets and separation and purification of the fission product molybdenum-99 (Mo-99) produced in these targets and the reuse of LEU within the HCF in compliance with the license issued under 10 CFR Part 50.

EMIF operations also include the fabrication and assembly of the LEU metal foil targets, which is a 10 CFR Part 70 licensed activity occurring within a facility licensed under 10 CFR Part 50. The targets are assembled and qualified at the HCF, within the EMIF, and transferred to the RF. The LEU used for the initial assembly of LEU target elements is obtained from the U.S. Department of Energy (DOE). After the initial phase of target irradiation and processing, subsequent target fabrication uses LEU reclaimed from target processing (blended with additional DOE material if necessary).

Design information for the various facility systems is provided throughout the PSAR and includes the following:

- Specific design criteria for SSCs are provided in this section and throughout the PSAR.
- Meteorological design bases describing the most severe weather extremes predicted to occur during the life of the facility are provided in Section 2.3. Design criteria for the facility SSCs to withstand the most severe weather extremes predicted to occur during the life of the facility are provided in Section 3.2.
- Hydrological design bases describing the most severe predicted hydrological events during the life of the facility are provided in Section 2.4. Design criteria for facility SSCs to withstand the most severe predicted hydrological events during the lifetime of the facility are provided in Section 3.3.
- Seismic design bases for the facility are provided in Section 2.5. Seismic design criteria for the facility SSCs are provided in Section 3.4.
- General design basis information relating to the safety and seismic classification of SSCs and to the associated quality levels (QL) being assigned is provided in Section 3.5.
- Design redundancy of safety-related SSCs intended to protect against unsafe conditions with respect to single failures is described in Chapters 6 and 7.
- Quality standards commensurate with the safety functions and potential risks are applied using a graded approach as described in the Eden Quality Assurance Program Description (QAPD). The QAPD is provided in Chapter 12.
- Postulated initiating events and credible accidents that form the design basis for the RF safety-related SSCs are discussed in Chapter 13a.
- Potential hazards and credible accidents that could be encountered during operations in the HCF involving special nuclear material, irradiated and unirradiated targets, Mo-99 recovery and purification, uranium recovery and recycle, waste management, and/or the

use of hazardous chemicals relative to these radiochemical processes that form the bases for the safety-related SSCs located in the HCF are discussed in Chapter 13b.

Pursuant to 10 CFR 50.34, an application for a Construction Permit must include the principal design criteria for a proposed facility. The principal design criteria establish the necessary design, fabrication, construction, testing, and performance requirements for SSCs that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public. The EMIF design criteria are selected to cover the following:

- Complete operating range for the HCF and RF.
- Responses of SSCs to anticipated operational transients and credible accidents.
- Design features for safety-related SSCs including redundancy, environmental qualification, and seismic qualification.
- Inspection, testing and maintenance of safety-related SSCs.
- Design features to prevent or mitigate the consequences of fires, explosions, and other manmade or natural conditions.
- Applicable quality standards.
- Analyses and design measures for meteorological, hydrological, and seismic effects.
- The bases for technical specifications that ensure the availability and operability of required SSCs.

Table 3.1-1 describes the design criteria for the EMIF.

3.1.1 NRC GUIDANCE DOCUMENTS

The NRC guidance documents considered in the design of the EMIF are identified in this PSAR and are listed in Table 3.1-2. The table shows the extent of usage of each guidance document in the PSAR by indicating the PSAR sections for which the document was used. Note that Division 1 Regulatory Guides are not applicable to non-power research and test reactors and are not included in this table. In some cases, portions of the Division 1 Regulatory Guides were utilized and are identified in sections throughout the PSAR, where NUREG-1537 and the associated ISGs were lacking in guidance.

3.1.2 CODES AND STANDARDS

Codes and standards used as guidance in the design of the safety-related SSCs are provided in Table 3.1-3. Other codes and standards are also identified throughout the PSAR.

Table 3.1-1
(Sheet 1 of 5)
EMIF Design Criteria

Design Criterion 1 **Quality Standards and Records**	Safety-related SSCs shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and are supplemented or modified as necessary to ensure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these SSCs satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of safety-related SSCs shall be maintained by or under the control of Eden throughout the life of the EMIF. Eden shall apply a graded approach to those items and activities that could affect the quality of SSCs, and other components not specifically designated as safety-related. A Quality Level description shall be used to ensure quality requirements are understood and specified for each SSC. Applicable activities shall be performed in accordance with the graded approach.
Design Criterion 2 **Design Bases for Protection Against Natural Phenomena**	Safety-related SSCs shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, and floods without loss of capability to perform their safety functions. The design bases for these SSCs shall reflect: (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed. Safety-related SSCs shall be protected from the adverse consequences of failure of those SSCs not specifically designated as safety-related.
Design Criterion 3 **Fire Protection**	Safety-related SSCs shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat-resistant materials shall be used wherever practical throughout the EMIF, particularly in locations containing safety-related SSCs. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on safety-related SSCs. Firefighting systems shall be designed to ensure that their rupture or inadvertent operation does not significantly impair the safety capability of these SSCs. The Eden Fire Protection Program shall address those SSCs not specifically designated as safety-related that could affect safety or the protection of licensed materials.
Design Criterion 4 **Environmental and Dynamic Effects Design Bases**	Safety-related SSCs shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. These SSCs shall be appropriately protected against dynamic effects and from events and conditions outside the facility. Safety-related SSCs shall be protected from the adverse consequences of failure of those SSCs not specifically designated as safety-related.

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Table 3.1-1
(Sheet 2 of 5)
EMIF Design Criteria

Design Criterion 5 **Sharing of Structures, Systems, and Components**	Safety-related SSCs shall not be shared between the RF and the HCF unless it can be shown that such sharing does not impair their ability to perform safety functions.
Design Criterion 6 **Reactor Design**	The reactor core and associated coolant, control, and protection systems shall be designed with appropriate margin to ensure that specified target design limits are not exceeded during any condition of normal operation, anticipated operational occurrences, and accident conditions.
Design Criterion 7 **Reactor Inherent Protection**	The reactor core and associated coolant systems shall be designed such that, in the power operating range, the net effect of the prompt inherent nuclear feedback characteristics compensates for a rapid increase in reactivity.
Design Criterion 8 **Instrumentation and Control**	Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to ensure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant boundary, and the confinement and its associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.
Design Criterion 9 **Reactor Coolant Boundary**	The reactor coolant boundary shall be designed, fabricated, erected, and tested so as to have a low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. The reactor coolant system and protection system shall be designed with sufficient margin to ensure that the design conditions of the reactor coolant boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences, and accident conditions.

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Table 3.1-1
(Sheet 3 of 5)
EMIF Design Criteria

Design Criterion 10 **Confinement**	Confinement system(s) shall be designed to limit the exchange of effluents between the confinement enclosure and its external environment to controlled or defined pathways. Systems to control fission products and other substances that may be released into the confinement atmosphere shall be provided as necessary to control releases to the environment following postulated accidents.
Design Criterion 11 **Electrical Power Systems**	Electrical power systems shall be provided to permit functioning, when required, of SSCs. The on-site electric power supplies, including the batteries, and the on-site electric distribution system, shall have sufficient independence and redundancy to perform their safety functions assuming a single failure.
Design Criterion 12 **Control Room**	A control room shall be provided from which actions can be taken to operate the reactor safely under normal conditions and anticipated operational occurrences. Measures are provided to permit access and occupancy of the control room during normal operation, anticipated operational occurrences, and egress under accident conditions.
Design Criterion 13 **Protection System Functions, Reliability, Testability, Independence, and Failure Modes**	The protection system shall be designed to automatically initiate protective functions which ensure that target design limits are not exceeded. The protection system shall be designed for high functional reliability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) no single failure results in loss of the protection function and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred. The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function or shall be demonstrated to be acceptable on some other defined basis.

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Table 3.1-1
(Sheet 4 of 5)
EMIF Design Criteria

Design Criterion 14 **Combined Reactivity Control Systems Capability, Reactivity Limits, and Protection Against Anticipated Operational Occurrences**	A reactor control system shall be designed to reliably control reactivity changes to ensure that, under accident conditions and with appropriate margin for a maximum worth stuck rod, acceptable target design limits are not exceeded. The reactor control system shall be designed, with margin for a maximum worth stuck rod, to maintain the reactor core subcritical under cold, clean conditions. The reactivity control system shall be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that the effects of postulated reactivity accidents cannot result in damage to the reactor target cladding or coolant boundary.
Design Criterion 15 **Reactor Coolant Makeup and Cleanup Systems**	A system to maintain reactor coolant inventory to make-up for losses from the reactor coolant pool boundary shall be provided. A system to maintain the required cleanliness of the reactor coolant shall be provided.
Design Criterion 16 **Heat Removal**	The reactor core cooling system shall be designed to remove sufficient heat from the reactor core to prevent target cladding failure during normal operation, anticipated operational occurrences and accident conditions.
Design Criterion 17 **Chemical Protection**	The design shall provide for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.
Design Criterion 18 **Control of Releases of Radioactive Materials to the Environment**	The facility design shall include means to control the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal operation, anticipated operational occurrences, and accident conditions. Holdup capacity, as necessary, shall be provided for retention of gaseous and liquid effluents containing radioactive materials.

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Table 3.1-1
(Sheet 5 of 5)
EMIF Design Criteria

Design Criterion 19 **Radioactive Material Control**	Target storage and handling, radioactive waste, and other systems that contain radioactivity shall be designed to ensure adequate safety under normal operation, anticipated operational occurrences, and accident conditions. Appropriate systems shall be provided in the facility (1) to detect conditions that may result in excessive radiation levels and (2) to initiate appropriate safety actions. These systems shall be designed with the capability to permit appropriate periodic inspection and testing.
Design Criterion 20 **Criticality Control**	Criticality shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations. A criticality accident alarm system shall be provided.
Design Criterion 21 **Monitoring Radioactivity Releases**	Means shall be provided for monitoring the RF and HCF atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operation, anticipated operational occurrences, and accident conditions. Means shall be provided, where necessary, to monitor radiation levels.
Design Criterion 22 **Inspection, Testing, and Maintenance**	The design of safety-related SSCs shall provide for adequate inspection, testing, and maintenance, to ensure their availability and reliability to perform their safety function when needed.
Design Criterion 23 **Biological Shielding**	Biological shielding shall be designed to protect the worker from unacceptable levels of radiation during normal operation, anticipated operational occurrences and accident conditions.

Abbreviations: EMIF = Eden Medical Isotope Facility | SSC = structure(s), system(s), and components | RF = Reactor Facility | HCF = Hot Cell Facility

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Table 3.1-2
NRC Guidance Considered in the Design

NRC Guidance	Title	PSAR Section
Regulatory Guide 2.5	Quality Assurance Program Requirements for Research and Test Reactors	12.9
Regulatory Guide 2.6	Emergency Planning for Research and Test Reactors	12.7
Regulatory Guide 3.71	Nuclear Criticality Safety Standards for Materials Outside Reactor Cores	6b.5, 7b.7
Regulatory Guide 4.21	Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning	11.1
Regulatory Guide 5.59	Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance	12.8
Regulatory Guide 8.2	Administrative Practices in Radiation Surveys and Monitoring	11.1
Regulatory Guide 8.4	Personnel Monitoring Device - Direct-Reading Pocket Dosimeters	11.1
Regulatory Guide 8.7	Instructions for Recording and Reporting Occupational Radiation Exposure Data	11.1
Regulatory Guide 8.9	Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program	11.1
Regulatory Guide 8.13	Instruction Concerning Prenatal Radiation Exposure	11.1
Regulatory Guide 8.25	Air Sampling in the Workplace	11.1
Regulatory Guide 8.29	Instruction Concerning Risks from Occupational Radiation Exposure	11.1
Regulatory Guide 8.34	Monitoring Criteria and Methods to Calculate Occupational Radiation Doses	11.1

Abbreviations: NRC = U.S. Nuclear Regulatory Commission | PSAR = Preliminary Safety Analysis Report

Table 3.1-3
(Sheet of 1 of 3)
Codes and Standards Used to Guide the Design of the Safety-Related SSCs

Safety-Related SSCs	Applicable Codes	PSAR Section(s)
RF building structure The concrete reactor pool structure and supporting base mat, and the transfer canal structure and supporting base mat	ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures (ACI, 2014) ANSI/AISC N690-18, Specification for Safety-Related Steel Structures for Nuclear Facilities (ANSI/AISC, 2018) ANSI/ANS 2.26-2004, Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design (ANSI/ANS, 2021) ASCE/SEI 4-16, Seismic Analysis of Safety-Related Nuclear Structures (ASCE/SEI, 2017b) IBC-2021, International Building Code (ICC, 2021) ASCE Manual of Practice No. 58, 1980 (ASCE, 1980) ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures (ASCE.SEI, 2017a) ASCE/SEI 43-19, Seismic Design Criteria for Structures, Systems and Components in Nuclear Facilities (ASCE/SEI, 2020)	3.2, 3.3, 3.4, 3.5, 6a.2
HCF building structure The concrete waste storage canyon structure and supporting base mat, the transfer canal structure and supporting base mat, the target processing canyon, canyon shield doors, and the structure housing the HCF Zone 1a ventilation system	ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures (ACI, 2014) ANSI/AISC N690-18, Specification for Safety-Related Steel Structures for Nuclear Facilities (ANSI/AISC, 2018) ANSI/ANS 2.26-2004, Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design (ANSI/ANS, 2021) ASCE/SEI 4-16, Seismic Analysis of Safety-Related Nuclear Structures (ASCE/SEI, 2017b)	3.2, 3.3, 3.4, 3.5, 6b.2

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Table 3.1-3
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Codes and Standards Used to Guide the Design of the Safety-Related SSCs

Safety-Related SSCs	Applicable Codes	PSAR Section(s)
HCF building structure (continued) The concrete waste storage canyon structure and supporting base mat, the transfer canal structure and supporting base mat, the target processing canyon, canyon shield doors, and the structure housing the HCF Zone 1a ventilation system	IBC-2021, International Building Code (ICC, 2021) ASCE Manual of Practice No. 58, 1980 (ASCE, 1980) ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures (ASCE.SEI, 2017a) ASCE/SEI 43-19, Seismic Design Criteria for Structures, Systems and Components in Nuclear Facilities (ASCE/SEI, 2020)	
Target elements	Not Applicable	4a.2, 7a.2
Control and safety rods	Not Applicable	4a.2, 7a.2
Reactor protection system	ANSI/ANS 15.15-1978, Criteria for the Reactor Safety Systems of Research Reactors (R1986) (ANSI/ANS, 1986)	7a.2, 7a.4
Steel confinement boxes (2 – 7)	American Glovebox Society (AGS)-G001-2007, Guideline for Gloveboxes, Third Edition AGS-G006-2017, Standard Practice for the Design & Fabrication of Nuclear Application Gloveboxes, Second Edition	4b.1, 6b.2, 9b.1

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Table 3.1-3
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Codes and Standards Used to Guide the Design of the Safety-Related SSCs

Safety-Related SSCs	Applicable Codes	PSAR Section(s)
HCF Zone 1a ventilation system	ASME AG-1, Code on Nuclear Air and Gas Treatment (ASME, 2023) ANSI/ASHRAE 62.1-2022, Ventilation and Acceptable Indoor Air Quality (ANSI/ASHRAE, 2022) ANSI/ASME N509-2002, Nuclear Power Plant Air-Cleaning Units and Components (R2008) (ANSI/ASME, 2008) ANSI/ASME N510-2007, Testing of Nuclear Air Treatment Systems (ANSI/ASME, 2007)	6b.2, 9b.1
Safety-related electrical power system	IEEE 308-2020, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations (IEEE, 2020) IEEE 338-2022, IEEE Standard for the Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems (IEEE, 2023) NFPA 70. National Electrical Code (NFPA, 2023)	6b.2, 8.3

Abbreviations: SSC = structure(s), system(s), and component(s) | PSAR = Preliminary Safety Analysis Report | RF = Reactor Facility | ACI = American Concrete Institute | ANSI = American National Standards Institute | AISC = American Institute of Steel Construction | ANS = American Nuclear Society | ASCE = American Society of Civil Engineers | SEI = Structural Engineering Institute | IBC = International Building Code | ICC = International Code Council | HCF = Hot Cell Facility | ASME = American Society of Mechanical Engineers | ASHRAE= American Society of Heating, Refrigerating and Air-Conditioning Engineers | IEEE = Institute of Electrical and Electronics Engineers | NFPA = National Fire Protection Association

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3.2 METEOROLOGICAL DAMAGE

This section describes the approach used to translate design basis meteorological parameters into loads for the design of safety-related SSCs. The design basis meteorological parameters are consistent with the findings of the site characterization analyses as described in Section 2.3.

The design basis meteorological parameters applicable to the design include those associated with normal wind loads, tornado loads, and precipitation loads. The EIPC site is sufficiently inland such that hurricane wind loads are not a consideration. The development and application of these loads is discussed in the following subsections. Evaluation of the EMIF for the meteorological loads is discussed in Subsection 3.5.2.2.1.

3.2.1 NORMAL WIND LOADING

The meteorological characterization of the EIPC site addressed the normal wind in Section 2.3. This subsection describes the approach to translating the normal winds for the site into loads on the EMIF.

There are safety-related SSCs in both the RF and HCF located in the EMIF, as discussed in Section 3.5. The design of the EMIF provides protection for safety-related SSCs against adverse effects from winds. The design basis normal wind loading conditions are discussed in the following subsections.

Wind loads affect the main wind force resisting system (MWFRS) structural elements of the EMIF that provide support and the stability for the overall structure, as well as the components and cladding. The components and cladding elements of the EMIF envelope are not required for structural integrity but are designed such that their failure does not affect safety-related SSCs.

3.2.1.1 Applicable Design Parameters

The local building code for the EIPC references American Society of Civil Engineers Structural Engineering Institute (ASCE/SEI) ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures, which defines risk categories for structures and provides design basis normal wind velocities for each risk category (ASCE/SEI, 2017a). Risk Category IV is the most stringent and is selected as the design basis for the EMIF because, according to the standard, it applies to buildings and other structures containing highly toxic substances. Per ASCE/SEI 7-16, the mean recurrence interval (MRI) of the basic wind speed for Risk Category IV buildings is 3000 years. Wind load determined for Risk Category IV buildings for the 3000-year MRI from ASCE/SEI 7-16, Chapters 26 to 30 is the “Strength Load” level wind. The 90 miles per hour (mph) (145 kilometers per hour [kph]) wind for the EIPC site in Lea County, New Mexico (NM), based on the 100-year mean return-interval 3-second gust wind speed at 33 feet (ft.) (10.1 meters [m]) identified in Subsection 2.3.2.2.5.1 is the “Service Load” level wind.

For the design of the MWFRS structural elements, the wind speed is transformed into applied load per ASCE/SEI 7-16, Chapter 27. In accordance with Figure 26.5-1D from ASCE/SEI 7-16 (ASCE/SEI, 2017a), the EMIF is designed to withstand the basic wind velocity of 120 mph (193 kph) based on a 3-second gust at 33 ft. (10.1 m) above ground for Risk Category IV structures in exposure category C. This wind speed bounds the 100-year mean return interval wind speed identified in Subsection 2.3.2.2.5.1. As described in Section 2.5, the terrain of the project site and the surrounding area is relatively flat. Based on the site characteristics, it is consistent with

ASCE/SEI 7-16 to use exposure category C to determine inputs for the computation of applied forces on structures as discussed in Subsection 3.2.1.2 and Subsection 3.2.1.3.

3.2.1.2 Determination of Applied Loads

In accordance with Equation 26.10-1 of ASCE/SEI 7-16 (ASCE/SEI, 2017a), the velocity pressure in pounds per square foot (lb/ft^2) is:

$$q_z = 0.00256K_zK_{zt}K_dK_eV^2 \quad (V \text{ in mph}) \qquad \text{(Equation 3.2-1)}$$

where:

q_z = velocity pressure at height (z)

K_z = velocity pressure exposure coefficient at height (z), as determined by Table 26.10-1 of ASCE/SEI 7-16, that corresponds to the height of the subject structure

K_{zt} = topographic factor, use 1.0 per Section 26.8.2 of ASCE/SEI 7-16

K_d = wind directionality factor of 0.85 for the MWFRS and components and cladding as determined by Table 26.6-1 of ASCE/SEI 7-16

K_e = ground elevation factor equal to 0.9 as determined by Table 26.9-1 of ASCE/SEI 7-16; minimum site elevation is 3343 ft. (1019 m) above mean sea level per Subsection 2.1.1.2

V = basic wind speed (3-second gust) of 120 mph (193 kph) as determined by Figure 26.5-1D of ASCE/SEI 7-16 for Risk Category IV, Exposure Category C Buildings and Other Structures

Both external and internal wind pressures are applied to the building model, consistent with the requirements of Section 27.3 of ASCE/SEI 7-16. Positive or negative internal pressure may be applicable to the internal surfaces of the exterior walls as well as the roof depending on the enclosure classification in addition to external (windward, leeward or side-wall) pressures at these surfaces.

3.2.1.3 Application of Normal Wind Load to Design of Structures

The calculated velocity pressure, as determined in Subsection 3.2.1.2, is applied in accordance with the provisions of Chapter 27 of ASCE/SEI 7-16 to confirm the EMIF design provides protection of safety-related SSCs against the effects of normal wind loads (ASCE/SEI, 2017a). See Section 3.5 for further discussion of design features that address loads from natural phenomena on the EMIF.

3.2.2 TORNADO LOADING

The meteorological characterization of the site defined the normal- and high-wind characteristics for the EIPC in Section 2.3. This subsection describes the approach to translating the characteristics of design basis tornadoes for the site into loads on the EMIF; specifically, safety-related portions and nonsafety-related structures that may adversely impact nearby safety-related SSCs. Tornado characteristics include high wind speed, atmospheric pressure change, and tornado-generated missile impacts. The design-basis-tornado loading conditions are discussed in the following subsections.

3.2.2.1 Applicable Design Parameters

The design of the EIPC is based on the Urenco USA (URENCO) facility design basis tornado and tornado missile criteria. The EIPC is located in eastern Lea County, NM, near the Texas and New Mexico border. The location of the EIPC in relation to the URENCO site is discussed in Subsection 2.3.1.

Both URENCO and EIPC rely on meteorological data from the Midland International Air and Space Port, Texas, weather observing station. A comparison of the meteorological parameters used for at URENCO (URENCO, 2005) and more recently collected data used for the EIPC shows no significant differences. The frequency and intensity of tornadoes has decreased slightly in the region of the EIPC and URENCO sites in the intervening time.

Because the EIPC site is close to the URENCO site and the meteorological values have not shown significant change since the URENCO site parameters were established, the URENCO site design parameters, including tornado missile spectrum, are considered representative of the EIPC site. The tornado parameters from the URENCO Safety Analysis Report (SAR) Subsection 3.2.3.4.1 (URENCO, 2005) are used for the design of the safety-related structures of the EIPC and are shown in Table 3.2-1. The NRC Safety Evaluation Report for the National Enrichment Facility in Lea County, New Mexico [URENCO] (NUREG-1827) concluded that the design-basis tornado parameters for URENCO were sufficient because these were determined using an acceptable method based on a 100,000-year return period. The corresponding facility tornado missile parameters are shown in Table 3.2-2.

3.2.2.2 Determination of Applied Forces

The approach used in Subsection 3.2.2.1 defines the tornado wind and tornado-generated missile loads on the facility but does not provide a method to determine their application. Although not strictly applicable to non-power reactor facilities, NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition, Section 3.3.2, Revision 3, “Tornado Loadings,” references ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, which does provide a method to determine applied forces from tornadoes (ASCE/SEI, 2006). Because ASCE/SEI 7-16 (ASCE/SEI, 2017a) is the code of record for the facility location’s local building code, the method from ASCE/SEI 7-16 is used to determine the applied forces on the safety-related portions of the EMIF from tornadoes using the design parameters defined in the previous section. To align the ASCE/SEI 7-16 equations with the ASCE/SEI 7-05 equations, the ground elevation factor (K_e) is considered to be 1.0 for tornado wind. ASCE/SEI 7-05 uses importance factors for wind loads, which have been removed from ASCE/SEI 7-16. Per Subsection 3.2.2.1 the tornado wind loads are taken from the URENCO SAR, which utilizes an importance factor of 1.0, as the safety factor is already included within the tornado design probability (URENCO, 2005). The velocity pressure calculated with ASCE/SEI 7-05 and a wind importance factor of 1.0 results in the same calculated pressures as ASCE/SEI7-16, and, therefore, ASCE/SEI 7-16 is used for the facility design of tornado wind loads.

In accordance with Equation 26.10-1 of ASCE/SEI 7-16 (ASCE/SEI, 2017a), the velocity pressure is determined using Equation 3.2-1 above,

where:

K_d = wind directionality factor equal to 1.0 (ASCE/SEI 7-16 Section C26.14.4)

K_e = ground elevation factor equal to 1.0

V = maximum tornado wind speed of 188 mph (303 kph)

The velocity pressure is not varied along the height of the building. The tornado differential pressure (atmospheric pressure change) is applied as an outward pressure to the exterior walls of the safety-related building as well as the roof.

ASCE Manual of Practice No. 58, Structural Analysis and Design of Nuclear Plant Facilities (ASCE, 1980), provides accepted methodologies for tornado missile barrier design and is implemented in the design of the EMIF. Concrete missile targets are designed using the modified National Defense Research Council formula (ASCE, 1980). Steel missile targets are designed using the Ballistic Research Laboratory formula (ASCE, 1980).

Applicable tornado effects are designated as tornado wind loads (W_w), tornado generated missile loads (W_m), and tornado atmospheric pressure loads (W_p). The total tornado load effect (W_T) is determined by combining the individual tornado loading components in accordance with Equations 3.2-2 through 3.2-4.

$$W_T = W_P \quad \text{(Equation 3.2-2)}$$

$$W_T = W_W + 0.5W_P \quad \text{(Equation 3.2-3)}$$

$$W_T = W_W + 0.5W_P + W_m \quad \text{(Equation 3.2-4)}$$

3.2.2.3 Overall Structural Response

In addition to local impact effects, the barriers and building structures are designed to resist the overall effects of missile impact or, alternatively, the overall effect on the safety-related SSCs from the missile impact is evaluated to ensure no safety function is compromised. The response of a structure to missile impact depends largely on the location of impact, the dynamic properties of the structure (target), and the kinetic energy of the missile. For tornado-generated missiles, a plastic collision between the missile and target is assumed in which all the missile momentum is transferred into the target. Based on this assumption and the assumption that the target has elasto-plastic behavior, expressions for an equivalent static load concentrated at the impact area can be determined (ASCE, 1980). Maximum allowable ductility ratios for steel and reinforced concrete are per American National Standards Institute (ANSI) American Institute of Steel Construction (AISC) document ANSI/AISC N690-18, Specification for Safety-Related Steel Structures for Nuclear Facilities (ANSI/AISC, 2018), and American Concrete Institute (ACI) document ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (ACI, 2014), respectively.

This load, in combination with other design loads, is evaluated using conventional design methods.

3.2.2.4 Effect of Failure of Structures, Systems, or Components Not Designed for Tornado Loads

The SSCs whose failure during a tornado event could affect the safety-related portions of the facility are designed to resist the tornado loading. This includes demonstrating that structural integrity is maintained for the nonsafety-related structures surrounding the safety-related RF and HCF structures. An alternative approach is to ensure that no safety-related function is compromised by failure of these SSCs.

3.2.3 SNOW, ICE, AND RAIN LOADING

The meteorological characterization of the EIPC site defines the precipitation characteristics (see Section 2.3). This subsection describes the approach to translating the characteristics of design basis precipitation for the site into loads on the EMIF. Precipitation categories include rain, snow, and ice. The exterior shell of the EMIF over the RF and HCF is provided with adequate primary and secondary drains to keep the rainwater to a level not governing the design. Therefore, loads due to rain accumulation are not considered in the structural design. Similarly, because rain accumulation does not occur, load due to ice is anticipated to be minimal and is thereby enveloped by the snow load. The design-basis-precipitation loading conditions are discussed in the following subsections.

3.2.3.1 Applicable Design Parameters

Based on the Risk Category IV characterization (see Subsection 3.2.1.1) and site location, Chapter 1, and Chapter 7 of ASCE/SEI 7-16 (ASCE/SEI, 2017a) provide snow load design parameters to be applied to the EMIF as discussed in Section 2.3. Rain on snow surcharge is addressed in the analysis consistent with Section 7.10 of ASCE/SEI 7-16 (ASCE/SEI, 2017a).

3.2.3.2 Determination of Applied Forces

The sloped roof snow load is calculated by Equation 3.2-6 as derived from ASCE/SEI 7-16, Sections 7.3 and 7.4 (ASCE/SEI, 2017a). The combined equation utilized to calculate the sloped roof load is:

$$p_s = 0.7 C_s C_e C_t I_s p_g \qquad \text{(Equation 3.2-5)}$$

where:

p_s = low-slope roof snow load (lb/ft^2)

C_s = roof slope factor as determined by Sections 7.4.1 through 7.4.4 of ASCE/SEI 7-16 corresponding to the geometry of the roof

C_e = exposure factor as determined by Table 7.3-1 of ASCE/SEI 7-16

C_t = thermal factor as determined by Table 7.3-2 of ASCE/SEI 7-16

I_s = importance factor as determined by Tables 1.5-1 and 1.5-2 of ASCE/SEI 716

p_g = ground snow load as determined in Section 2.3 to be 12.2 lb/ft^2 (59.6 kilograms per square meter), for MRI = 100 year

Unbalanced snow loads on the roof of the EMIF are determined in accordance with Section 7.6 of ASCE/SEI 7-16, and design snow drift loads are determined in accordance with Section 7.7.

Table 3.2-1
Design-Basis Tornado Field Characteristics

Description	Value
Annual Tornado Hazard Probability	1 E-05
Tornado Wind Speed	188 mph
Radius of Damaging Winds	425 ft.
Atmospheric Pressure Change (APC)	80 lb/ft^2
Rate of APC	30 lb/ft^2/second

Note: Based on a 100,000-year period of recurrence.
Abbreviations: mph = miles per hour | ft. = feet | lb. = pounds | ft^2 = square feet

Table 3.2-2
Design-Basis Tornado Missile Spectrum

Description	Weight	Dimensions	Horizontal Velocity	Vertical Velocity	Maximum Height above Ground
Timber Plank	15 lb.	2 in. x 4 in.	85 mph	55 mph	200 ft.
Steel Pipe	75 lb.	3-in. diameter	50 mph	30 mph	30 ft.
Automobile	3000 lb.	N/A	20 mph	N/A	N/A

Abbreviation: lb. = pound(s) | in. = inch(es) | mph = miles per hour | ft. = feet | N/A = not applicable

3.3 WATER DAMAGE

This section describes how the EMIF is adequately protected from postulated internal and external flooding events and thus from water damage.

3.3.1 FLOOD PROTECTION

3.3.1.1 External Flood Protection Design Features

The hydrological characterization in Section 2.4 indicates that because there are no permanent bodies of water, reservoirs, or impoundments in the site vicinity, the only potential flooding of the facility results from local intense rainfall.

Per Section 2.4, there is no evidence that the site area has experienced flooding in the past. Additionally, the site is located at a higher elevation than the immediate surrounding area. Section 2.4 describes the design basis flooding event expected at the site. Protection against the design external flood level is provided by establishing the facility floor level 0.5 ft. (0.15 m) above the high point of finished grade elevation and all roads at least 1.5 ft. (0.45 m) below facility floor level to support drainage of flood waters. Exterior or access openings and penetrations into the EMIF are above the design external flood level and thus do not require protection against flooding. Grading and drainage on the EIPC site preclude water accumulation around the EMIF and prevent precipitation loads from affecting the EMIF. In addition, to prevent general site flooding from the contributory areas above the site, diversion ditches are strategically located around the site to deflect surface runoff from adjacent land away from the facility structures on the site. Based on these design features, the probability of the water level reaching the EMIF finished floor is negligible.

There are no external flood loads on the above-grade portion of the EMIF. The portion of the EMIF below-grade (reactor pool, transfer canal, waste storage canyon, activation isotope processing area, and other HCF basement areas) could be subjected to grade-level hydrologic loads. However, they are constructed of reinforced concrete designed to meet ACI 349-13 (ACI, 2014). The weight of the building offsets the potential buoyant forces due to a postulated external flood on the below-grade, safety-related portion of the EMIF.

The following features are included to prevent water intrusion and provide protection to the safety-related systems and components in the EMIF:

- The safety-related portions of the building that are below-grade are constructed of reinforced concrete designed to meet ACI 349-13 requirements (ACI, 2014).
- Water stops are provided in construction joints below grade level.
- Waterproof coating is applied to external surfaces of the EMIF exposed to flood level.
- Exterior or access openings and penetrations into the EMIF are above the maximum postulated flooding level and thus do not require protection against flooding.
- As noted in Subsection 3.2.3, roofs are designed to prevent pooling of large amounts of water.

Water from tanks and piping that are nonsafety-related, and not protected against missiles, represent potential flooding sources outside of the EMIF. In the absence of final pipe routing information, expected flooding hazards from on-site sources are discussed generically. There

are no large tanks or water sources near the EMIF or entrances to the EMIF. Flooding that may result from tank or pipe rupture would drain away from the EMIF because of the grading and drainage on the EIPC site. Additional detail on the design features will be provided in the application for the Operating License.

Therefore, the EIPC site is designed such that safety-related SSCs have adequate external flood protection.

3.3.1.2 Internal Flood Protection Design Features

Postulated flooding from SSC failure in the EMIF is prevented from adversely affecting safety-related SSCs or posing any hazard to the public.

The liquid effluent control system (LECS) room contains three 10,000-gallon (37.9 cubic meter) holding tanks that are surrounded by a dry concrete berm with a minimum capacity to accommodate a potential failure of two tanks. Thus, flooding of the EMIF due to a LECS tank failure is not credible.

There is no high-energy piping in the EMIF design; therefore, a high energy break is not considered.

Per Section 4a.3, the reactor pool in the RF contains water filled to a level (i.e., reactor pool water level) that is below the top of the surrounding area floor slab. The reactor pool contains an overflow drain that impedes overflowing of the reactor pool onto the first floor, and the robust design of the pool, including the stainless-steel liner, precludes leaks. These features prevent the loss of a significant amount of pool water such that its contribution to flooding is not credible.

Internal flooding in the EMIF, which houses safety-related SSCs, is due to the following potential sources: water-containing reactor support systems, the fire protection water system, and the potable water system. There are other small sources of water that support facility processing; however, volumes of these small sources are not expected to result in internal flooding greater than flooding due to the above systems. Pipes, vessels, and tanks with the potential to flood safety-related portions of the RF are seismically qualified in accordance with local building code and consistent with seismic design category (SDC) based on the safety classification of the SSCs. Furthermore, design features such as mounting or locating above flood heights are used to protect safety-related equipment sensitive to water (e.g., instrumentation and electrical components). Finally, per Section 4a.1, the all-target reactor does not require any active systems to be operable once the reactor is shut down (control rods and safety rod in their full down position). In these ways, postulated flooding from component failures inside the building compartments is prevented from adversely affecting facility safety or posing any hazard to the public.

The extent of flood protection for safety-related SSCs for internal flooding is determined by the maximum flow rate and the volume of water available to feed a postulated break. Furthermore, because the ability of other water-containing systems to impact safety-related components is limited, discharge from the operation of the fire protection system represents the limiting condition for internal flooding to impact the safety-related systems, bounding the water accumulation potential from other sources, including piping failure within the fire protection, potable water, or reactor support systems. The design of the facility for fire suppression systems using water (e.g., automatic sprinklers, hose stations) includes elements such as the grading and channeling of floors, curbs, raising of equipment pads and mounts above floors, shelving

and floor drains, and other passive means of protecting equipment from flooding. Furthermore, where there is concern for radiological fluid or radionuclides in the room or area and fire suppression is required, curbs are in place to contain the fire suppression fluid so it can be collected until it is sampled and properly disposed of. The method of collection will be described in the Operating License Application. These features ensure sufficient capacity for gravity-driven collection and drainage of the maximum water discharge rate and duration to avoid localized flooding and resulting water damage to equipment within the area. Fire protection water falling onto the surface of the reactor pool from sprinklers overhead does not adversely affect the RF safety-related SSCs. In addition, automatic or operator actions are provided to terminate flow from the fire protection pump(s).

In addition, particularly sensitive systems and components are protected within enclosures designed for the anticipated adverse environmental conditions resulting from these types of water discharges to ensure that sprinkler discharge does not adversely affect their operation. Where safety-related, water-sensitive systems or components must be installed in areas having water-based fire suppression, the appropriate severe environment-rated enclosures are used in accordance with the relevant industry standard(s) (e.g., National Electrical Manufacturers Association enclosure standards). Additional detail on the design features will be provided in the application for the Operating License.

Therefore, the EMIF is designed such that safety-related SSCs are not affected by the postulated internal flood event.

3.3.2 STRUCTURAL DESIGN FOR FLOODING

The only potential external flooding of the facility results from local intense rainfall. With the design external flood level at grade elevation, there is no dynamic force due to precipitation or flooding on the above-grade portions of the structure.

The structure below-grade is designed for grade-level hydrologic loads, including both hydrostatic and hydrodynamic loads generated during accident conditions.

Regarding structural design for internal flooding, the design of the facility for fire suppression systems using water also includes a drainage system that prevents substantial loading due to water collection on the first floor or second floor slabs.

3.4 SEISMIC DAMAGE

Seismic analysis criteria for the EMIF within the EIPC comply with relevant portions of 10 CFR 50.34, which provides generic requirements and guidance for the licensing of nuclear facilities. Guidelines for preparing license applications for non-power reactors are provided in NUREG-1537 and the ISG Augmenting NUREG-1537. The methodologies and criteria provided in ASCE/SEI 4-16, Seismic Analysis of Safety-Related Nuclear Structures (ASCE/SEI, 2017b), and ASCE/SEI 43-19, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities (ASCE/SEI, 2020), are used to perform the seismic analysis of the EMIF.

The EIPC contains safety-related and nonsafety-related buildings. These include buildings containing radiologically controlled areas, non-uranium related process areas, areas for short-term storage of product, other ancillary spaces, and administrative offices. The EMIF houses the utilization and production facility and contains the only safety-related areas on the site. The planned safety-related underground structures include a below-grade reactor pool, a transfer canal, and a waste storage canyon. The major structural elements of the EMIF include the reinforced concrete foundation mat, reinforced concrete walls, reinforced concrete floor/roof slabs, and structural steel members. The EMIF building is designed to protect the people, materials, and equipment inside the facility from natural and manmade accidents. The EMIF structure is described in more detail in Subsection 3.5.2.1.

The EMIF contains safety-related SSCs. The shipping/receiving areas and other areas around the outside of the EMIF contain only nonsafety-related support systems and equipment.

3.4.1 SEISMIC DESIGN BASIS

Seismic analysis and design of the safety-related structures within the EMIF implement the graded approach in ANSI/American Nuclear Society (ANS) document ANSI/ANS-2.26-2004, Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design (R2021) (ANSI/ANS, 2021), in which the required level of rigor for analysis and design is based on hazard level and consequences of failure.

The set of requirements or Seismic Design Basis (SDB) of the SSCs is determined based on the selected SDC and Limit State (LS) following ASCE/SEI 43-19 (ASCE/SEI, 2020). The SSC SDC is selected based on the unmitigated consequences of failure to the facility workers, public, and environment. The SSC LS is selected based on the acceptable deformation, displacement, or stress that an SSC may experience during and after an earthquake and still perform its safety function. Target performance goals for each SDC and acceptable deformations for each LS are listed in Table 3.4-1 and Table 3.4-2, respectively. The target performance goal is the target annual frequency of an SSC exceeding its specified LS.

ANSI/ANS-2.26-2004 (ANSI/ANS, 2021) provides guidelines for selecting the SDC and LS for seismic analysis and design of SSCs. Based on the unmitigated consequences of SSC failure listed in Table 1 of ANSI/ANS-2.26-2004, safety-related building structures are assigned SDC-3. LS “C,” for which an SSC may sustain minor permanent distortion (require no post-earthquake repair) but shall still perform its safety function, is assigned to the safety-related building structures. Therefore, the SDB for the safety-related building structures within the EMIF is categorized as SDC-3C. For all other safety-related SSCs, the developed SDC-3 criteria shall be used, and the applicable LS is selected based on the acceptable level of deformation/damage.

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Nonsafety-related SSCs for which there are no radiological release consequences are assigned SDC-1 whose design requirements are provided in the International Building Code (IBC) (ICC, 2021). No LS identification is required for SDC-1 per ANSI/ANS-2.26-2004 (ANSI/ANS, 2021). All other nonsafety-related SSCs that cannot be assigned SDC-1 (i.e., failure may result in small/localized radiological release consequences) shall be evaluated in accordance with the SDC-3 criteria used for safety-related SSCs because SDC-2 criteria are not developed.

Using the analysis procedures of ASCE/SEI 4-16 (ASCE/SEI, 2017b) to predict seismic demands and the design procedures of ACI 349-13 (ACI, 2014) and ANSI/AISC N690-18 (ANSI/AISC, 2018), the SDB achieves the following goals for the safety-related structures within the EMIF:

- Less than 1 percent probability of unacceptable performance for the Design Basis Earthquake (DBE) ground motion.
- Less than 10 percent probability of unacceptable performance for a ground motion equal to 150 percent of the DBE ground motion.

3.4.2 SEISMIC INPUT

3.4.2.1 Design Response Spectra

As described in Subsection 2.5.5, the U.S. Geological Survey National Seismic Hazard Model is used to determine the Uniform Hazard Response Spectra for the site. The horizontal Design Response Spectrum (DRS) for the site is determined following the procedure in ASCE/SEI 43-19 (ASCE/SEI, 2020) to achieve the target performance goal of 1.0E-4 for the SDC-3 safety-related structures as described in Subsection 2.5.5.

The DRS and seismic demands for SDC-1 structures follow IBC-2021 (ICC, 2021) which refers to ASCE/SEI 7-16 (ASCE/SEI, 2017b). The DRS for nonsafety-related structures are determined based on Section 11.4 of ASCE/SEI 7-16, which uses the risk-targeted maximum considered earthquake (MCER) maps in Chapter 22 of ASCE/SEI 7-16. The risk category (Table 1.5-1 of ASCE/SEI 7-16) is determined for each nonsafety-related structure. The target reliability (conditional probability of failure) caused by the MCER for each Risk Category is shown in Table 1.3-2 of ASCE/SEI 7-16.

3.4.2.2 Design Time Histories

For soil-structure interaction (SSI) analysis and generating in-structure response spectra (ISRS), design acceleration time histories are required. Modified recorded acceleration time histories are generated to match (envelop) the DRS. The ground motion acceleration time histories are generated in accordance with the criteria and requirements described in Section 2.6 of ASCE/SEI 4-16 (ASCE/SEI, 2017b) and Section 2.4 of ASCE/SEI 43-19 (ASCE/SEI, 2020). One ground motion history consists of three mutually orthogonal modified recorded acceleration time histories, one for each horizontal direction and one for the vertical direction. Each of the time histories must meet the DRS enveloping requirements described in Section 2.4 of ASCE/SEI 43-19 (ASCE/SEI, 2020).

3.4.2.3 Critical Damping Values

Structural damping values provided in Table 3.4-3 for various structural elements used in the seismic analyses are based on ASCE/SEI 4-16 (ASCE/SEI, 2017b) and ASCE/SEI 43-19 (ASCE/SEI, 2020) provisions. The specified damping values depend on component types and response level. At response level 1, the structural demands of beams and columns are less than 50 percent and reinforced concrete members are not significantly cracked. At response level 2, member demands are generally between about 50 percent and 100 percent of the nominal strength. At response level 3, structures behave beyond the elastic range with limited permanent distortion to large permanent distortion. Table 3.4-4 provides a summary of the response levels, and Table 3.4-5 shows the maximum response levels that can be used for selecting the damping value in several analysis types.

For structural systems with different damping properties, the composite damping in Section 3.5.2 of ASCE/SEI 4-16 (ASCE/SEI, 2017b) can be used. In the modal analysis of structures composed of different materials having different damping values, whether using the response spectrum method or the time-history method, the composite modal damping is calculated using either the stiffness-weighted method or mass-weighted method as shown in Section 3.5.3 of ASCE/SEI 4-16 (ASCE/SEI, 2017b).

3.4.3 SEISMIC ANALYSIS OF FACILITY STRUCTURES

3.4.3.1 Seismic Analysis Methods

Regardless of the method selected for the seismic analysis, the solution to the following general equation of motion is required:

$$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = -[M]\{\ddot{u}_g\} \qquad \text{(Equation 3.4-1)}$$

where:

$[M]$ = mass matrix

$[C]$ = damping matrix

$[K]$ = stiffness matrix

$\{\ddot{x}\}$ = column vector of relative accelerations

$\{\dot{x}\}$ = column vector of relative velocities

$\{x\}$ = column vector of relative displacements

$\{\ddot{u}_g\}$ = ground acceleration

Therefore, the physical structure must be converted to an idealized analytical model, such that the parameters $[M]$, $[C]$, and $[K]$ are correctly represented and reasonably capture the dynamic characteristics of the structure. This subsection provides details for developing analytical models of the structures to represent their mass, damping, and stiffness characteristics.

In general, three-dimensional models should be used for seismic analysis. However, simpler models can be used if justification can be provided that the coupling effects of the degrees of freedom (DOF) omitted from the three-dimensional models are not significant.

Consistent with Section 3.1.3 of ASCE/SEI 4-16 (ASCE/SEI, 2017b), the type of finite element used for modeling a structural system should depend on structural details, the purpose of analysis, and the theoretical formulation upon which the element is based. The mathematical discretization of the structure should consider the effect of element size, shape, and aspect ratio on solution accuracy.

For the EMIF, the finite element analysis model consists of plate/shell elements representing walls, slabs, and foundations. The finite element model uses beam elements for steel structural members and additional nodal masses are used to represent seismic mass from sources other than the explicitly modeled structural components and equipment (if any). Seismic masses are considered in the model according to Section 3.4 of ASCE/SEI 4-16 (ASCE/SEI, 2017b) as shown below.

- Dead load: 100 percent.
- Live load: Minimum of 25 percent of specified design live load for design loads 200 pounds per square foot (lb/ft^2) and smaller. Not less than 50 lb/ft^2 for design loads greater than 200 lb/ft^2. The percent of the live load considered present during the seismic event is dependent on the type of live load and the type of structural idealization (i.e., total weight considered for live loads such as movable equipment or storage that are always present while minimum considered for operating decks/laydown areas not used during normal operation).
- Snow load: 25 percent of uniform design snow load where design flat roof snow loads are greater than 30 lb/ft^2. Where the design flat roof snow load is less than 30 lb/ft^2, no snow mass is included.

Consistent with Section 4 of ASCE/SEI 4-16 (ASCE/SEI, 2017b), the following methods are acceptable for performing seismic analysis of structures. These methods can be used for seismic analysis of safety-related SSCs and nonsafety-related structures in the EMIF.

- Response spectrum analysis (modal superposition).
- Time history analysis (modal superposition).
- Time history analysis (direct integration).
- Time history analysis (frequency domain).
- Equivalent static analysis.

For SSI analysis of the EMIF, the time history analysis method in the frequency domain is used to determine seismic behavior of the building. When using the modal superposition method in time-history and response spectrum analyses, the equation of motion for an undamped system is decoupled into single-DOF equations, using the modal characteristics of the system.

Each decoupled equation is solved for the given input motion, and the total response of the system is obtained by combining the corresponding responses. The input motion can be specified either in terms of an acceleration time history or response spectrum. The method for

combining responses from the decoupled equation of motion depends on the method of analysis.

3.4.3.1.1 Response Spectrum Analysis Method

A response spectrum represents the ensemble of maximum responses of a series of single-DOF systems with varying frequencies and damping values to the same base input motion. The maximum modal responses of a multi-DOF system are calculated directly from the input response spectrum.

The maximum responses are then combined using one of the acceptable methods provided in Chapter 4 of ASCE/SEI 4-16 (ASCE/SEI, 2017b).

3.4.3.1.1.1 Modal Response Combination

The total response of a system is divided into two parts. The low frequency flexible (periodic) response is due to modes with frequencies less than the frequency at which the spectral acceleration approximately returns to the Zero Period Acceleration (ZPA). The high frequency rigid response is due to modes with frequencies approximately equal to or greater than the spectrum ZPA frequency. Modes in the transition region between low and high frequencies contain both flexible and rigid responses.

For the general case in which both periodic and rigid modes and those modes in the transition region between the periodic and rigid regions occur, the Gupta method or Lindley-Yow method of combining modal response is used.

The residual rigid response can be calculated as described in Subsection 3.4.3.1.1.4 and considered as an additional rigid mode that is algebraically summed with the other rigid responses and rigid components of responses. This method requires the computation of individual modal responses only for lower-frequency modes while ensuring all modes of the structural model are included and DOF masses are properly represented. Thus, the more difficult higher-frequency modes need not be determined in the analysis.

The resulting total rigid response shall be combined with the flexible response by the square root of the sum of squares (SRSS) method.

3.4.3.1.1.2 Combination of Flexible Responses

Acceptable procedures for combining modal responses are the Complete Quadratic Combination (CQC) method and others that account for the effect of closely spaced modes. The flexible modal responses for a specific direction of seismic input motion are combined using the CQC/double sum method equation below.

$$R_p = \sqrt{\sum_{k=1}^{n}\sum_{s=1}^{n} R_k R_s \varepsilon_{ks}} \qquad \text{(Equation 3.4-2)}$$

where:

n = Numbers of flexible modes

R_p = The maximum value of a particular response of a given element to a given component of earthquake due to flexible response

R_k, R_s = The peak values of the responses of the element due to the k^{th} and s^{th} modes, respectively

ε_{ks} = Rosenblueth Correlation Coefficient or Der Kiureghian Correlation Coefficient

3.4.3.1.1.3 Combination of Rigid Responses

In the high frequency region, rigid responses dominate. In the transition region between low and high frequency, the modal responses consist of both flexible and rigid components. The high frequency rigid responses and transition region rigid components of responses are algebraically summed using the equation below.

$$R_r = \sum_{i=1}^{n} R_{ri} \quad \text{(Equation 3.4-3)}$$

where:

n = Numbers of modes considered

R_r = The maximum value of a particular response of a given element to a given component of earthquake due to rigid response

R_{ri} = The rigid response or rigid component of a response of the element due to i^{th} mode

3.4.3.1.1.4 Calculation of High Frequency Residual Rigid Response

The following method for determining the high frequency residual rigid response is generally referred to as the missing mass approach. The steps of the method are as follows:

a. Determine the modal responses for modes with natural frequencies less than that at which the spectral acceleration approximately returns to the ZPA.
b. For each DOF included in the dynamic analysis, determine the fraction of mass included in the summation of all the modes included in Step 1. The fraction d_i for each DOF i is given by:

$$d_i = \sum_{n=1}^{N} \left(C_{n,j} \varphi_{n,i} \right) \quad \text{(Equation 3.4-4)}$$

where:

n = mode number

N = number of modes included in Step 1

$\varphi_{n,i}$ = eigenvector value for mode n and DOF i

j = direction of input motion

$C_{n,j}$ = participation factor for mode n in the j^{th} direction

$$C_{n,j} = \frac{\{\varphi_n\}^T [M]\{\delta_{ij}\}}{\{\varphi_n\}^T [M]\{\varphi_n\}} \quad \text{(Equation 3.4-5)}$$

δ_{ij} is the Kronecker delta, which is one if DOF i is in the direction of the earthquake motion and zero if DOF i is a rotation or not in the direction of earthquake input motion

M is the mass matrix

Next, determine the fraction of DOF mass not included in the summation of these modes:

$$e_i = d_i - \delta_{ij} \quad \text{(Equation 3.4-6)}$$

c. Higher modes are assumed to respond in phase with the ZPA and thus with each other. Hence, these modes are combined algebraically, which is equivalent to pseudo-static response to inertial forces from these higher modes excited at the ZPA. The pseudo-static inertial forces associated with the summation of all higher modes not included in Step 1 for each DOF i are given by:

$$P_i = ZPA \times M_i \times e_i \quad \text{(Equation 3.4-7)}$$

where:

P_i = the force or moment to be applied at DOF i

M_i = the mass or mass moment of inertia associated with DOF i

The system is then statically analyzed for this set of pseudo-static inertial forces applied to all DOF to determine the maximum responses associated with high-frequency modes not included in Step 1 (residual rigid response). The residual rigid response is considered an additional mode and algebraically summed with other rigid responses or rigid components of responses as described in Subsection 3.4.3.1.1.3.

3.4.3.1.2 Time History Analysis in Time Domain

3.4.3.1.2.1 Modal Superposition Method

For time history analysis performed using the modal superposition method, the decoupled equation of motion for each lower frequency mode (modes with frequencies less than the ZPA frequency) is solved in the time domain on a step-by-step basis using closed form integration. The modal responses from these modes of the system are algebraically summed at each time step. Thus, a time history of the response values is obtained.

The residual rigid response due to mass excited in modes with natural frequencies higher than the ZPA frequency that is not captured in the modal analysis (missing mass) must also be calculated and included. An approach analogous to that described in Subsection 3.4.3.1.1.4 may be used in the modal superposition time history analysis in which the missing mass contribution (scaled to the instantaneous input acceleration rather than ZPA) is treated as an additional mode and algebraically summed with the modal analysis responses at each time step.

3.4.3.1.2.2 Direct Integration Method

For time history analysis performed using the direct integration method, the coupled equations of motion are directly solved in the time domain using acceptable step-by-step numerical integration techniques such as the Newmark–β method, Wilson–θ method, and central difference method.

3.4.3.1.3 Time History Analysis in Frequency Domain

In frequency domain time history analysis, the input time history is transformed into the frequency domain using Fourier transform techniques to solve the equations of motion. Once the solution is obtained in the frequency domain, the response can be transformed back into the time domain using the inverse Fourier transform. The computer program used for the SSI analysis is SASSI2010, which utilizes frequency domain analysis (SASSI, 2012a).

3.4.3.1.4 Equivalent Static Analysis

In the equivalent static analysis method, a static analysis of the system is performed with static forces at the structural mass locations. This method is intended for relatively simple systems. The static force is a gravity acceleration coefficient, C, applied to the modeled mass. The acceleration coefficient value C is obtained from the applicable horizontal and vertical response spectra curves (DRS for SSCs founded on ground and ISRS for SSCs supported by another structure).

Consistent with Section 4.5 of ASCE/SEI 4-16 (ASCE/SEI, 2017b), an equivalent static method is acceptable if:

- Justification is provided that the system can be realistically represented by a simple model and the method produces conservative results in terms of responses.
- The design and associated simplified analysis account for the relative motion between all points of support.

In determining the gravity acceleration coefficient C, a factor of 1.5 is applied to the peak spectral acceleration of the applicable floor response spectrum. A factor of less than 1.5 may be used following Section 4.5.1 of ASCE/SEI 4-16 (ASCE/SEI, 2017b).

3.4.3.2 Soil-Structure Interaction Analysis

Frequency domain time history analysis that considers complex frequency response is used to perform SSI analysis of the EMIF. SASSI2010 simulates the interaction between the structure-soil system and has two methods for performing SSI analysis: (i) direct flexible volume method and (ii) subtraction method. In the direct flexible volume method, the complete soil-structure system is partitioned into three substructures, namely, the free field site, the excavated soil

volume, and the structure. Interaction between the free field and excavated soil volume occurs at all excavated soil volume nodes (Figure 3.4-1). The structure interacts with the free field and excavated soil volume at the side and bottom boundaries of the embedded portion of the structure foundation. In the subtraction method, the same substructuring as the direct flexible volume method is used, but the interaction nodes are only defined at the side and bottom boundaries of the excavated volume. The SSI analysis is performed using either the direct flexible volume method or the modified subtraction method (or extended subtraction method as denoted in SASSI2010 User's Manual [SASSI, 2012a]). In the modified subtraction method, additional nodes within the excavated soil volume are defined as interaction nodes.

SASSI2010 is a linear analysis program. The iteration on the strain-compatible soil properties is not directly incorporated in the analysis. The equivalent linear soil properties (soil shear modulus and damping) compatible with seismic strains induced in the free field due to the DBE motion are used in the analysis. The equivalent strain-compatible soil properties obtained in the free field due to the ground motion are called the primary nonlinearity. Any further nonlinear effect in the soil due to SSI effects is called secondary nonlinearity. The secondary nonlinearity effects are neglected in the SSI analysis because they are not significant.

3.4.3.2.1 Soil-Structure Interaction Analysis Model

For SSI analysis using SASSI2010, the model consists of three parts (Figure 3.4-1):

- Free-field soil model – the strain-compatible soil properties obtained from the Site Response Analysis are input to the SSI analysis model. The soil layer thickness values used in the model must be fine enough to ensure transmittal of the highest frequency of interest in the analysis. For this purpose, the layer thickness smaller than or equal to one-fifth of the highest frequency of interest wavelength in the soil layer is used. The layer thickness h is given by the following equation:

$$h \leq \frac{V_s}{(5 \times f)} \qquad \text{(Equation 3.4-8)}$$

  where:

  V_s = the shear wave velocity in the soil layer media

  f = the highest frequency of interest

- Excavated soil model – The excavated soil is modeled using solid elements in the entire excavated volume (embedded portion of structural model). The layering of the excavated soil volume solid elements and associated soil properties are the same as those in the free-field soil model.
- Structural model – The EMIF model is primarily a 3-D finite element model. The major walls and slabs of the building are modeled using shell elements. Major steel sections and columns are modeled using beam elements.

The SSI analyses are performed for the mean best estimate (BE), upper bound (UB), and lower bound (LB) soil properties. Two model configurations are also considered; one to capture the effect of lateral separation between the structure and the lateral soil and another to capture the effect of concrete cracking. For the lateral separation, no connectivity between the structure and

the lateral soil is assumed over the upper half of the embedment or 20 ft. (6.1 m), whichever is less, per Section 5.1.9 of ASCE/SEI 4-16 (ASCE/SEI, 2017b). The model for the cracked concrete case is identical to the uncracked case except that the stiffness of the concrete sections is reduced by 50 percent based on Table 3-2 of ASCE/SEI 4-16 (ASCE/SEI, 2017b).

Additional calculation is performed to show the backfill soil properties are within the UB and the LB soil properties used in the SSI analysis. Typical backfill soil properties are based on granular soil compacted to minimum 95 percent Proctor density (85 percent relative density). If the backfill soil properties are not bounded by the LB and UB soil properties, additional cases may be required to determine the effect of the backfill on the seismic behavior of the EMIF.

The response results from the analyzed cases are enveloped. This conservative approach is used to account for uncertainties resulting from variations of material properties and to keep the SSI model size within a manageable limit.

The in-situ soil profiles are determined based on geotechnical investigation of the nearby URENCO site. The soil properties include standard penetration test results, soil layer thickness, shear wave velocity, shear modulus, unit weight, Poisson’s ratio, and damping. Due to the proximity, these properties are considered representative for the EIPC site. Site-specific investigations will be performed to confirm this similarity. Strain-compatible dynamic soil properties and design seismic input motions (DRS) are generated by site response analysis. A brief description of the procedure follows:

a. Develop base case soil profile and properties, including parameters to characterize the variability.
b. Develop simulated profiles including uncertainties in the data.
c. Perform site response analysis of the simulated soil profiles.
d. Compute strain-compatible soil properties and mean response motions at the foundation elevation.

The site response analysis determines the BE, LB, and UB strain-compatible soil properties and the Foundation Input Response Spectra to perform SSI analysis of the EMIF.

The main production facility of the EMIF building consists of safety-related production areas and nonsafety-related service areas on a common foundation. The weight and stiffness of the nonsafety-related structures are included in the seismic analysis of the EMIF building.

3.4.3.2.2 Generation of In-Structure Response Spectra

For each input motion direction, two horizontal and one vertical response spectra are computed for each desired damping value from the time history motions output at the various floors and major equipment support locations within the supporting structure. The co-directional spectral amplitudes from the three directions of excitation are combined using the SRSS method to determine the ISRS. These ISRS are used to determine seismic demands of secondary systems and components in the building. The frequencies used in development of the ISRS are selected up to a maximum frequency of 50 hertz in accordance with Section 6.2.2 of ASCE/SEI 4-16 (ASCE/SEI, 2017b).

Consistent with Section 6.2.3 of ASCE/SEI 4-16 (ASCE/SEI, 2017b), the final enveloped floor response spectra are peak widened by ± 15 percent on the frequency scale to account for uncertainties in parameters such as material properties of the structure and soil and approximations in the modeling technique used in the analysis.

3.4.3.2.3 Interpolation of Response Spectra for Unknown Damping

Response spectral acceleration values are provided for various critical damping values such as 0.5 percent, 2.0 percent, 5.0 percent, 7.0 percent, and 10.0 percent. If spectral values for other damping values are required, the following procedure provided in ASCE/SEI 4-16 (ASCE/SEI, 2017b) is used to interpolate the spectral amplitude for any intermediate damping value.

Response spectra that are not available may be generated by linear interpolation for intermediate levels of damping with the interpolation in terms of the natural logarithm of damping. Another method to determine response spectra (S) for a damping value (λ) from known spectral acceleration values (S_1, S_2) for two adjacent damping values (λ_1, λ_2) is to use the following equation, provided that $\lambda_1 < \lambda < \lambda_1 \leq 3\lambda_1$:

$$S = \sqrt{S_2^2 + (S_1^2 - S_2^2)(\lambda_1/\lambda)(\lambda - \lambda_2)/(\lambda_1 - \lambda_2)} \quad \text{(Equation 3.4-9)}$$

3.4.3.3 Combination of Earthquake Components

In order to account for the responses of the structures subjected to the three directional (two horizontal and one vertical) excitations, the maximum co-directional responses are combined using the SRSS method or the 100-40-40 rule per ASCE/SEI 4-16 (ASCE/SEI, 2017b) to determine the total response in each direction. The SRSS method of combination may be used when the responses are obtained using the response spectrum method, time history method (separate analysis for each component of excitation), equivalent static method, and frequency domain method (SSI analysis using SASSI2010). ASCE/SEI 4-16 (ASCE/SEI, 2017b) also allows the use of the 100-40-40 rule in which the maximum co-directional responses for each component of seismic input are combined, and all possible combinations are evaluated to determine the most critical response.

For time history analysis that is performed separately for each of the three statistically independent components (cross-correlation coefficient between each pair of components is less or equal to 0.16), the total response may alternatively be obtained by algebraically summing the co-directional responses at each time step from each component of seismic input. The maximum combined response from all time steps is used in design.

3.4.3.4 Seismic Analysis Results

The following provides the summary of results obtained from the seismic analyses of the EMIF. All seismic responses are obtained from SSI analysis using SASSI2010 simulations.

- Maximum seismic demands (moment, shear, axial force) in the structure obtained from the SSI analysis models.
- Un-widened horizontal and vertical acceleration response spectra at all building floor elevations and at other selected nodes with various damping values (e.g., 2 percent, 3

percent, 4 percent, 5 percent, 7 percent, and 10 percent).

- Peak widened generic site-envelope horizontal and vertical acceleration response spectra enveloping all SSI cases. The spectra are peak widened by ± 15 percent (at each spectral frequency).
- Maximum absolute horizontal and vertical accelerations at all building floor elevations and other selected locations.
- Generic site-envelope absolute horizontal and vertical accelerations.
- Generic site-envelope maximum relative displacement with respect to motion at grade level in the free-field.
- Maximum relative displacement with respect to motion at grade level at desired locations.

3.4.3.5 Assessment of Structural Seismic Stability

The stability of the EMIF is evaluated for sliding and overturning due to the DBE considering the following load combinations and factors of safety in accordance with Section 7.2 of ASCE/SEI 43-19 (ASCE/SEI, 2020):

	Minimum Factor of Safety	
Load Combination	Sliding	Overturning
$D + H + E'$	1.1	1.1

where:

D = Dead Load

H = Lateral Earth Pressures

E' = Earthquake Load

The lateral driving forces in the seismic stability evaluation of the EMIF include forces such as active lateral soil force, static surcharge lateral soil force, dynamic surcharge lateral soil force, dynamic lateral soil force, and seismic lateral inertial force, if applicable. The resistance for sliding is due to the static friction at the soil-basemat interface for sliding evaluation and passive lateral soil resistance. The self-weight of the structure is considered in the resistance to overturning effects.

3.4.4 SEISMIC QUALIFICATION OF SUBSYSTEMS AND EQUIPMENT

In general, one of the following four methods of seismically qualifying the SSCs is chosen based upon the characteristics and complexities of the subsystem:

- Dynamic analysis.
- Testing.
- Comparison with existing databases.

- A combination of analysis and testing.

The methods to be used for qualification are stated below. These methods depend on the type of equipment and supporting structure. The following defines some of the possible cases and associated analytical methods which may be used in each case. ISRS for the EMIF are used to determine the appropriate seismic demands of equipment, piping, and components in the safety-related envelope. For the evaluation of cable and conduit raceway systems, quantitative evaluation criteria are applied only to the most seismically vulnerable portions of these systems.

3.4.4.1 Qualification by Analytical Methods

Analytical calculations may be used as a qualification method when maintaining the structural integrity is necessary to ensure the SSC can perform its safety function. This method can be used for equipment and piping systems for which expected response to the earthquake excitations can be characterized as linear or simple non-linear behavior (e.g., piping, skids, and large equipment). ISRS discussed in Subsection 3.4.2.2 are used in the response spectrum analysis of piping and equipment. These response spectra are used to determine the seismic requirements at the component mounting locations for qualification purposes and for piping subsystem dynamic analysis.

3.4.4.1.1 Equivalent Static Analysis

The equipment, as well as its support, can be considered rigid if it can be shown that its fundamental natural frequency does not fall in the frequency range below the high frequency asymptote (ZPA) of the required response spectrum (RRS). For rigid equipment supported by a rigid structure, the equipment motion shall be the same as the floor motion without amplification. The horizontal and vertical dynamic accelerations shall be taken as the ZPA from the applicable ISRS. In this case, the dynamic forces are determined by multiplying the mass of the subassembly or parts of the equipment by the ZPA of the ISRS. These forces should be applied through the center of gravity of the subassembly or the part of the equipment.

When the equipment and support system’s natural frequency falls in the frequency range below the high frequency asymptote (ZPA) of the applicable RRS, the accelerations to be used are obtained from the appropriate ISRS curves at each natural frequency in the frequency range of interest. If the frequency information is not available, the equivalent static analysis is performed using 1.5 times the maximum peak spectral acceleration of the applicable ISRS. The dynamic amplification factor of 1.5 may be reduced following Section 4.5.1 of ASCE/SEI 4-16 (ASCE/SEI, 2017b), if needed.

The stresses resulting from each force (in each of the three directions) should be combined by an appropriate combination method to yield the dynamic stresses. The dynamic deflections (deflections due to dynamic loads) may be calculated in the same manner. These dynamic stresses and deflections are combined with stresses and deflections from other loads per the load combinations defined in the applicable design codes.

3.4.4.1.2 Detailed Dynamic Analysis

When acceptable justification for static or simplified dynamic analysis cannot be provided, a detailed dynamic analysis is performed. A mathematical model may be constructed to represent the dynamic behavior of the equipment. A finite element model may be constructed and analyzed using response spectrum modal analysis or time-history analysis. The maximum

inertia forces, at each mass point, from each mode, are applied at that point to calculate the modal reactions (forces and moments) and modal deformations (translations and rotations). The various modal contributions are combined by an appropriate combination method. Closely spaced modes are combined using an appropriate approach such as the CQC method discussed in Subsection 3.4.3.1.1.2. The stresses and deflections resulting from each of the three directions are combined to obtain the dynamic stresses and deflections. These dynamic stresses and deflections are combined with stresses and deflections from other loads per the load combinations defined in the applicable design codes.

3.4.4.2 Qualification by Tests

Seismic qualification by testing follows Section 8.3 of ASCE 43-19 (ASCE/SEI, 2020). Qualification by test is typically used for SSCs for which qualification by analysis is not permitted and for SSCs where dynamic behaviors are not sufficiently understood to support qualification by analysis.

The vibration inputs for the seismic tests are the response spectra or Required Input Motion (typical for line-mounted equipment) at the mounting location of the equipment. ISRS are used to develop Test Response Spectra for testing.

The tested equipment samples shall be mounted to simulate the recommended service mounting. If this cannot be done, the effect of the actual supporting structure shall be considered in determination of the input motion. Any mass attached to the component during the postulated dynamic event shall be simulated during the test, unless the supporting test (or calculations) shows that they are insignificant.

At the completion of the tests, inspection shall be made by the test technician to confirm that no structural damage has occurred. Sufficient monitoring devices shall be used to evaluate the performance of the active components during the tests. For acceptability, the components shall demonstrate their ability to perform their intended safety functions when subjected to all applicable loads.

3.4.4.3 Comparison with Existing Databases

ISRS are used to develop RRS for comparison with existing response from a database. The candidate equipment must be similar to equipment in the existing seismic experience databases.

3.4.4.4 Combined Methods of Qualification

Based on the available information, component complexity, and functional requirements, the above mentioned analytical and test methods may be combined in various ways to achieve seismic qualification of the subject components.

3.4.5 SEISMIC INSTRUMENTATION

Seismic instrumentation is not required under Section IV(a)(4) of Appendix S to 10 CFR Part 50 or Section VI(a)(3) of Appendix A to 10 CFR Part 100 because the EIPC is not a nuclear power station. However, the facility has nonsafety-related seismic instrumentation to record accelerations experienced at the site during a seismic event. This instrumentation is sufficiently robust to meet this design objective.

The seismic instrumentation establishes the acceptability of continued operation of the facility following a seismic event. This system provides acceleration time histories or response spectra experienced at the facility to assist in verifying that safety-related SSCs within the EMIF can continue to perform their safety functions.

Table 3.4-1
Target Performance Goal

Seismic Design Category	1[(a)]	2	3[(b)]	4	5
Target Performance Goal	1×10^{-3}	4×10^{-4}	1×10^{-4}	4×10^{-5}	1×10^{-5}

a) Nonsafety-related SSCs for EIPC are designated as SDC-1. The mean seismic failure probability of building structures designed to the IBC-2021 (ICC, 2021) is estimated to be $<1 \times 10^{-3}$/year.
b) Safety-related SSCs for EIPC are designated as SDC-3.
Abbreviations: SSC = structure(s), system(s), and component(s) | EIPC = Eden Isotope Production Complex | IBC = International Building Code

Table 3.4-2
Deformation and Damage by Limit State

Limit State	Acceptable Deformation	Acceptable Damage
A	Large permanent distortion, short of collapse and instability	Significant
B	Moderate permanent distortion	Generally repairable
C[(a)]	Limited permanent distortion	Minimal
D	Essentially elastic behavior	Negligible

a) Limit State C is adopted for safety-related SSCs.
Abbreviations: SSC = structure(s), system(s), and component(s)

Table 3.4-3
Damping Values for Dynamic Analysis

Type of Component		Damping		
		Response Level 1	Response Level 2	Response Level 3
Welded and friction-bolted steel structures		2	4	7
Bearing-bolted steel structures		4	7	10
Prestressed concrete structures (without complete loss of prestress)		2	5	7
Reinforced concrete structures		4	7	10
Steel-plate composite walls		3	5	10
Reinforced masonry shear walls		4	7	10
Piping		5	5	5
Heating, Ventilation, and Air Conditioning	Pocket Lock	7	10	[a]
	Companion Angle	5	7	
	Welded	3	4	
Distribution Systems	Cable trays 50% or more full and in-structure response spectrum ZPA of 0.25 g or greater	5	10	15
	For other cable trays, cable trays with rigid fireproofing and conduits	5	7	7
Massive, low-stressed mechanical components (e.g., pumps, compressors, fans, and motors)		2	3	[a]
Light welded instrument racks		2	3	[a]
Electrical cabinets and other equipment		3	4	5[b]
Liquid containing tanks	Metal – Impulsive mode	2	3	4
	Reinforced concrete – Impulsive mode	3[c]	5	7
	Sloshing mode	0.5	0.5	0.5

a) Should not be stressed to Response Level 3.
b) May be used for anchorage and structural failure modes that are accompanied by at least some inelastic response. Response Level 1 damping values shall be used for functional failure modes such as relay chatter or relative displacement issues that may occur at a low cabinet stress level.
c) If an unlined tank is intended to function as a liquid retention barrier, then the tank should not be stressed beyond Response Level 1.
Abbreviations: ZPA = zero period acceleration | g = standard acceleration due to gravity

Table 3.4-4
Damping Response Level

Response Level	(Elastic Demand) / (Nominal Strength)
1	≤ 0.5
2	0.5 to 1.0
3	≥ 1.0

Table 3.4-5
Summary of Maximum Response Level for Damping

Analysis	Maximum Response Level
Elastic buckling conditions control design	1
Generation of in-structure response spectra	1 (2, if justified)
Elastic analysis	3[a]
Inelastic time-history response analysis	1 (2, if justified)

a) Only to be used with adequate ductile detailing. However, functionality of SSCs must be given due consideration. Response Level 3 corresponds to Limit State C; Response Level 3 may also be used for Limit States A and B.
Abbreviations: SSC = structure(s), system(s), and component(s)

3.5 STRUCTURES, SYSTEMS, AND COMPONENTS

3.5.1 GENERAL DESIGN BASIS INFORMATION

The SSC designs are based on the design criteria described in Section 3.1. The design and implementation of the safety-related SSCs are based on applicable regulatory guidance, design criteria, requisite codes, standards, and appropriate quality assurance measures. The design approach and formal implementation processes, as described in the Eden QAPD, and implementing procedures serve as the foundational basis for defense-in-depth practices that provide reasonable assurance that safety-related SSCs can perform as intended.

The design of the facility and systems is based on defense-in-depth practices. Defense-in-depth practices refers to a design philosophy, applied from the outset and through completion of the design, that is based on providing successive levels of protection such that health and safety are not wholly dependent upon any single element of the design, construction, maintenance, or operation of the facility. The net effect of incorporating defense-in-depth practices is a conservatively designed facility and systems that exhibit a high level of tolerance to failures and external challenges. The risk insights obtained through performance of accident analysis supplement the final design by focusing attention on the prevention and mitigation of higher risk potential accidents.

The facility and system design incorporates a preference for engineered controls over administrative controls and independence to avoid common mode failures. The design also incorporates other features that enhance safety by reducing challenges to safety-related components and systems.

Physical separation and electrical isolation are used to maintain the independence of safety-related control circuits and equipment among redundant safety divisions or from nonsafety systems so that the safety functions required during and following accident events can be accomplished.

Safety-related SSCs form the key elements of the overarching set of “engineered controls” that fulfill regulatory requirements and specifically address concerns identified in the Chapter 13 safety analysis.

The design bases for the SSCs are described in detail throughout this PSAR. Sections of the PSAR where SSCs are described also provide information for consideration in the technical specifications. This includes limiting conditions for operation, setpoints, design features, and means for accomplishing surveillances. Proposed testing to confirm that performance levels meet functional safety requirements and verification of the adequacy of system design will be provided as part of the startup test plan (Section 12.11) provided in the Operating License Application.

3.5.2 CLASSIFICATION OF STRUCTURES, SYSTEMS, AND COMPONENTS

SSCs are assigned safety, seismic, and quality classifications consistent with their safety functions. These classifications are described below. Tables 3.5-1a and 3.5-1b provide a summary of these classifications for the RF and HCF, respectively.

Systems and components in the EMIF are classified according to their safety classification, QL, and seismic class. The following subsections provide the high-level guidance used in developing these classifications during preliminary design with the support of regulatory guidance reviews, hazard and operability studies, accident analysis, integrated safety analysis, and national consensus code requirements.

As described in Tables 3.5-1a and 3.5-1b, Design Criteria 1 through 4 apply to the RF and HCF building structures, respectively. Compliance with additional design criteria for the RF and HCF are described in Sections 6a.2 and 6b.2, respectively.

3.5.2.1 Description of Plant Structures

The EIPC contains safety-related and nonsafety-related buildings. These include buildings containing radiologically controlled areas, non-uranium related process areas, areas for short-term storage of product, other ancillary spaces, and administrative offices. The EMIF houses the utilization and production facilities and contains the only safety-related areas on the site. The safety-related areas within the EMIF are located within the RF and the HCF. Figure 3.5-1 identifies the safety-related and nonsafety-related portions of the EMIF structure.

The safety-related structural portions of the EMIF consist of the reactor pool structure and base mat concrete, the transfer canal structure and base mat concrete, the HCF uninterruptible electrical power supply system room, the HCF mechanical equipment room housing the HCF Zone 1a fan/filter trains, and the HCF target processing canyon/waste storage canyon reinforced concrete walls, slabs and base mat. The foundation for the safety-related structures is below-grade mat slabs. The safety-related structures are shear wall systems mainly constructed of reinforced concrete. The major structural elements of the safety-related EMIF include the reinforced concrete foundation mat, reinforced concrete walls, and reinforced concrete floor/roof slabs. The roof of the HCF target processing canyon consists of a series of removable concrete slabs that remain in place while the HCF is in operation. The reactor pool and transfer canal do not have a reinforced concrete roof. The transfer canal has a cover to provide a foreign material exclusion barrier. The potential impact of tornado missiles on the top of the reactor pool and transfer canal is addressed using probabilistic analysis, as discussed in Subsection 3.5.2.2.1.

The nonsafety-related structural portions of the EMIF are identified in Figure 3.5-1 and consist of the RF high bay, the HCF high bay, and the adjacent areas. The outer shell of the EMIF structure is nonsafety-related. The nonsafety-related portions of the EMIF are steel frame construction with a mat slab foundation. The nonsafety-related foundation is separate and isolated from the safety-related foundation. The isolation is provided by a gap located between the nonsafety-related grade foundations and the safety-related foundations. The gap is large enough to accommodate seismic displacements. Above grade floors are reinforced concrete slabs on steel beams. The nonsafety-related portion of the EMIF does not support any safety-related SSCs.

3.5.2.2 Structural System Evaluation

Although the nonsafety-related portion of the EMIF surrounds the safety-related portion of the EMIF, the nonsafety-related portion is not credited to provide physical protection to safety-related SSCs from the effects of normal or high winds or from the effects of DBEs. The nonsafety-related portion of the EMIF is also not credited to provide protection to safety-related

SSCs from the effects of water damage. However, the design of the exterior roof precludes adverse effects related to accumulation of water and ice.

The safety-related portion of the EMIF is under the Quality Assurance Program described in Chapter 12. The safety-related portion of the EMIF is designed for the normal structural loading based on the local building code (IBC-2021 [ICC, 2021]) and augmented for specific design basis natural phenomena such as extreme wind, flooding, and earthquake, as described below.

3.5.2.2.1 Evaluation for Meteorological Loads

Subsection 3.2.1 describes the normal wind loads used as design parameters for the safety-related portion of the EMIF. Loads from normal winds are in the form of velocity pressure. Subsection 3.2.2 describes the high wind loads from tornadoes used as design parameters for the EMIF; specifically, the safety-related portions and nonsafety-related structures that may adversely impact nearby safety-related SSCs. Loads from high winds are in the form of velocity pressure, atmospheric pressure change, and tornado missile impacts. Subsection 3.2.3 describes the precipitation loads used as design parameters for the safety-related portion of the EMIF.

Protection of safety-related SSCs from tornado missile impacts is achieved using two complementary design methodologies. First, the structural components of safety-related structures are designed for both local and global damage due to tornado missile impacts. Any safety-related SSC that is within the safety-related structures and not exposed by openings or penetrations is therefore protected from damage caused by tornado missiles. Second, a probabilistic analysis is conducted to ensure that the openings within the safety-related structures do not expose safety-related SSCs to an unacceptable probability of tornado missile impact. Openings in safety-related structures that would expose safety-related SSCs as potential missile targets are evaluated. The probability analysis is conducted consistent with the guidance in Appendix G of NUREG/CR-4710, Shutdown Decay Heat Removal Analysis of a Combustion Engineering 2-Loop Pressurized Water Reactor. The number of potential missiles on the site is taken from Nuclear Energy Institute (NEI) document NEI 17-02, Tornado Missile Risk Evaluator Industry Guidance Document (NEI, 2017), which is considered conservative given the smaller site size of the EIPC compared to a nuclear power plant. NUREG-0800, Section 2.2.3, states that an acceptable probability for design basis events is an order of magnitude of 10^{-7} per year. While the EMIF is not required to adhere to the guidance in NUREG-0800, this probability is conservatively used here. The probability analysis concludes that a tornado missile strike on the vulnerable openings in the safety-related structures is not a credible event because the probability is orders of magnitude lower than 10^{-7}.

The safety-related portion of the EMIF is a reinforced concrete structure designed to meet the provisions of ACI 349-13 (ACI, 2014). Internal safety-related steel structures are designed in accordance with the provisions of ANSI/AISC N690-18 (ANSI/AISC, 2018). Both ACI 349-13 and ANSI/AISC N690-18 are standards specific to the design of safety-related nuclear structures and have built-in margin. By designing the safety-related portion of the EMIF in accordance with these two standards, the safety-related portion of the EMIF is capable of resisting the design basis loads discussed in Section 3.2.

3.5.2.2.2 Evaluation for Flood Loads

Section 3.3 describes the design basis flood parameters for the safety-related portion of the EMIF. As noted in Section 3.3, there are no external flood loads on the above-grade portion of

the EMIF. The portion of the EMIF below-grade (reactor pool, transfer canal, waste storage canyon, and other HCF basement areas) could be subjected to grade-level hydrologic loads. The EMIF is designed to withstand buoyant forces and groundwater, including groundwater associated with the design basis flood. See Section 3.3 for further discussion on flood mitigation measures and evaluations.

3.5.2.2.3 Evaluation for Seismic Loads

Section 3.4 describes the DBE characteristics used as the design input for the safety-related portion of the EMIF. The safety-related portion of the EMIF is designed to be consistent with the graded approach in ANSI/ANS-2.26-2004 (ANSI/ANS, 2021), in which the required level of rigor for analysis and design is based on hazard level and consequences of failure. As discussed in Section 3.4, the SDB for the safety-related building structures within the EMIF is categorized as SDC-3C. The methodologies and acceptance criteria provided in ASCE/SEI 4-16 and ASCE/SEI 43-19 (ASCE/SEI, 2017b; ASCE/SEI, 2020) are used to perform the seismic analysis for the EMIF. The seismic soil pressure on subgrade walls is determined based on either results of the SSI analysis or simplified approaches per Chapter 8 of ASCE 4-16 (ASCE/SEI, 2017b). When using SSI analysis results to determine seismic soil pressures, soil-structure connectivity shall be assumed over the entire embedment height. Alternatively, a simplified method for seismic soil pressure calculation is based on parabolic distributions of soil pressure that are applied to an equivalent static seismic design model. Structural demands are determined based on the results of the analysis discussed in Section 3.4. In addition to the seismic effects, the effects from gravity and other concurrent loading are considered on the structural demands. ACI 349-13 and ANSI/AISC N690-18 (ACI, 2014; ANSI/AISC, 2018) are used to design a structure that can withstand the seismic demands specified in Section 3.4. By designing the safety-related portion of the EMIF in accordance with these two standards, the safety-related portion of the EMIF is capable of resisting the design basis loads discussed in Section 3.4.

3.5.2.3 Overall Structural System Evaluation

The safety-related structures constructed of reinforced concrete are designed in accordance with the applicable load combinations from Subsection 9.2.1 of ACI 349-13 (ACI, 2014). The safety-related structures constructed of structural steel are designed in accordance with the applicable load combinations from Section NB2 of ANSI/AISC N690-18 (ANSI/AISC, 2018).

The nonsafety-related portion of the EMIF is designed to the local building code, which is the IBC (ICC, 2021). The local building code for the EMIF invokes ASCE/SEI 7-16 (ASCE/SEI, 2017a) for minimum design load requirements. In addition to being designed for local building code requirements, the main force resisting system (MFRS) of the nonsafety-related portion of the EMIF is designed for the extreme environmental loads discussed in Sections 3.2 through 3.4. The nonsafety-related portion of the EMIF MFRS is designed for collapse prevention for these additional loads to ensure it does not negatively impact the safety-related portion of the EMIF.

Additional detail about the structural design features for the safety-related portion of the EMIF, informed by the results of the analysis, will be provided in the application for the Operating License.

3.5.3 SAFETY CLASSIFICATION

All SSCs in the EMIF have two possible safety classifications: safety-related or nonsafety-related.

These SSCs are assigned a nuclear safety classification as follows:

Safety-related SSCs: Those SSCs that are applied to prevent accidents that could cause undue risk to health and safety of workers and the public and to control or mitigate the consequences of such accidents. Safety-related SSCs ensure:

- The capability to shut down the reactor and maintain the reactor in a safe shutdown condition.
- The capability to protect against an acute worker dose of 5 rem or greater total effective dose equivalent (TEDE).
- The capability to protect against an acute dose of 1 rem or greater TEDE to any individual located outside the owner controlled area.
- The capability to protect against an intake of 30 milligrams or greater of uranium in a soluble form by any individual located outside the owner controlled area.
- The capability to protect against an acute chemical exposure to an individual from licensed material or hazardous chemicals produced from licensed material that could lead to irreversible or other serious, long-lasting health effects to a worker or could cause mild transient health effects to any individual located outside the owner controlled area.
- The capability to protect against a criticality event in the HCF.

Nonsafety-related SSCs: Those SSCs that are not in the above safety classification.

3.5.4 SEISMIC CLASSIFICATION

As discussed in Section 3.4, seismic analysis and design of the safety-related EMIF implement the graded approach in ANSI/ANS-2.26-2004 (ANSI/ANS, 2021) in which the required level of rigor for analysis and design is based on hazard level and consequences of failure.

The set of requirements or SDB of the SSCs is determined based on the selected SDC and LS, following ASCE/SEI 43-19 (ASCE/SEI, 2020). The SSC SDC is selected based on the unmitigated consequences of failure to the facility workers, public, and environment.

SSCs are designed according to their safety classification. The EMIF is classified as SDC-3, consistent with ASCE/SEI 43-19 (ASCE/SEI, 2020). All safety-related SSCs are located in the safety-related portions of EMIF. LS “C” has been adopted for safety-related SSCs.

The credited safety systems designed to function in a postulated event are described in Chapter 13.

Seismic qualification is accomplished through analysis, testing, or a combination of those methods, following ASCE/SEI 43-19. Acceptance criteria are defined in accordance with

ASCE/SEI 43-19 (ASCE/SEI, 2020) and/or its references. Section 3.4 discusses seismic qualification in more detail.

Nonsafety-related SSCs for the EMIF are designated as SDC-1. SSCs that are nonsafety-related are designed in accordance with local building code IBC-2021 (ICC, 2021), as discussed further in Section 3.4.

3.5.5 QUALITY LEVEL CLASSIFICATIONS

The design criteria are implemented using a graded approach to quality as described in the Eden QAPD provided in Chapter 12. The graded approach process establishes the level of analysis, documentation, and actions necessary to comply with a requirement that is commensurate with the safety function. The graded approach permits resources to be focused on those activities that are deemed, by qualitative analysis, to reduce the associated risks and hazards.

QL are assigned to activities and tasks performed in accordance with approved implementing processes and procedures to include the facility design and construction.

The Eden QAPD has been developed in accordance with ANSI/ANS 15.8-1995, Quality Assurance Program Requirements for Research Reactors (R2018) (ANSI/ANS, 2018), and provides the following graded approach to quality:

- QL-1 implements the full measure of the Eden QAPD and is applied to safety-related SSCs and safety-related activities.
- QL-2 is applied to selected SSCs and activities intended to support or protect the safety-related activities.
- QL-3 is applied to nonsafety-related SSCs and activities that do not support or protect the safety function of safety-related SSCs or activities. However, the performance of QL-3 SSCs and activities may be important to ensuring that customer requirements are met or for investment protection. Controls appropriate for the application are applied to SSCs and activities, using elements of the Eden QAPD for efficiency to avoid the creation and use of a separate or redundant management system. The controls on these SSCs and activities do not impact QL-1 or QL-2 SSCs and activities or the regulatory basis of the facility.

Table 3.5-1a
(Sheet 1 of 2)
Classification of Reactor Facility Structures, Systems, and Components

Structure, System, Component Name	RF Design Criteria[c]	Safety Class[a,b]	Seismic Class	Quality Class	PSAR Section(s)
RF building structure The concrete reactor pool structure and supporting base mat, and the transfer canal structure and supporting base mat.	5,9,16,18,22,23	SR	3	1	3.5.2 6a.2.1
Balance of RF building structure	10,18	NSR	1	2	3.5
Reactor control room	12	NSR	1	2	7a.2, 7a.6
Reactor pool liner	9,18,23	NSR	1	2	4a.3
Transfer canal liner (common with HCF)	9,18,23	NSR	1	2	4a.3
Target elements	6,7,22	SR	3	1	1.3.9, 4a.2.1
Control and safety rods	6,13,14,22	SR	3	1	4a.2.2, 7a.2
Reactor Core support structure, beryllium reflector, neutron source	6,7	NSR	1	2	4a.2.5, 4a.5.1, 4a.6.1
Target handling system	19,20	NSR	1	2	9a.2.1
Target transfer system (common with HCF)	19,20	NSR	1	2	9a.2.2
Reactor primary coolant system	6,9,16,19	NSR	1	2	5a.2
Reactor secondary coolant system	6,16,19	NSR	1	2	5a.3
Reactor primary coolant cleanup system	9,15,19	NSR	1	2	5a.4
Reactor primary coolant makeup system	15	NSR	1	2	5a.5
Reactor protection system	6,8,13,22	SR	3	1	7a.2, 7a.4

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Table 3.5-1a
(Sheet 2 of 2)
Classification of Reactor Facility Structures, Systems, and Components

Structure, System, Component Name[d]	RF Design Criteria[c]	Safety Class[a,b]	Seismic Class	Quality Class	PSAR Section(s)
Facility control system	8,14	NSR	1	2	7a.2, 7a.3
RF high bay ventilation system	8,10,18,21	NSR	1	2	9a.1.1
RF general area HVAC	12	NSR	1	3	9a.1.2
Liquid effluent control system (common with HCF)	18, 19, 21	NSR	1	2	11.2.2
Normal and backup electrical power system (common with HCF)	11	NSR	1	2	8.1,8.2
Radiation monitoring system (common with HCF)	19, 21	NSR	1	2	7a.2, 7a.7, 11.1
Fire detection/suppression system (common with HCF)	3	NSR	1	2	9a.3
Other Auxiliary Systems	3	NSR	1	3	9a.7

a) SR = safety-related; NSR = nonsafety-related
b) Safety classification accounts for the highest classification in the system. Systems that are classified as safety-related may include both safety-related and nonsafety-related components. Only safety-related components are used that satisfy the safety functions of the system, whereas nonsafety-related components can be used to perform nonsafety functions.
c) Design criteria 1 – 4 from Table 3.1-1 are not specifically listed but are generally-applicable to all systems. Based on the classification and location of the SSCs, design criteria are applied, as required, using a graded approach as described in the Eden QAPD. The compliance of NSR systems with the generally-applicable design criteria will be further described in the Operating License Application.
d) Nonsafety-related systems without an applicable design criterion are not listed.

Abbreviations: RF = Reactor Facility | PSAR = Preliminary Safety Analysis Report | HCF = Hot Cell Facility | HVAC = heating, air conditioning, and ventilation | SSC = structure(s), system(s), and component(s)

Table 3.5-1b
(Sheet 1 of 2)
Classification of Hot Cell Facility Structures, Systems, and Components

Structure, System, Component Name[d]	HCF Design Criteria[c]	Safety Class[a,b]	Seismic Class	Quality Class	PSAR Section(s)
HCF building structure The concrete waste storage canyon structure and supporting base mat, the transfer canal structure and supporting base mat, the target processing canyon, canyon shield doors, and the structure housing the Zone 1a ventilation system	5,10,18,22,23	SR	3	1	3.5, 6b.2
Balance of HCF building structure	10,18	NSR	1	2	3.5
Transfer canal liner (common with RF)	9,18,23	NSR	1	2	4a.3
Target transfer system (common with RF)	19,20	NSR	1	2	9a.2.2
Steel confinement boxes (2 – 7)	10,17,20,22	SR	3	1	4b.1.2, 6b.2, 9b.1.1
Steel confinement boxes (1, 8 – 19)	10,17,20	NSR	1	2	4b.1.2, 9b.1.1
SCB process cooling	18,19	NSR	1	2	5b
SCB material transfer system	18,19	NSR	1	2	4b.1.2, 9b.2.2
Fission Gas Delay System	18,19	NSR	1	2	4b.3.3
HCF Zone 1a ventilation system	8,10,18,21,22	SR	3	1	6b.2.2, 9b.1.1
HCF Zone 1 (b, c, d) ventilation system	8,10,18,21	NSR	1	2	9b.1.1
HCF Zone 2 ventilation system	8,10,18,21	NSR	1	2	9b.1.1
HCF Zone 3 ventilation system	8,10,18,21	NSR	1	2	9b.1.1
Canyon shield door control system	8,10,23	NSR	1	2	4b.1.2, 7b.2.1, 7b.3.5
SCB processing system controls	17,18	NSR	1	2	7b.3.2

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Table 3.5-1b
(Sheet 2 of 2)
Classification of Hot Cell Facility Structures, Systems, and Components

Structure, System, Component Name	HCF Design Criteria[c]	Safety Class[a,b]	Seismic Class	Quality Class	PSAR Section(s)
Waste handling control system	18,19	NSR	1	2	7b.3.8
Criticality accident alarm system	20	NSR	1	2	6b.5.1, 7b.7.3.1
Normal and backup electrical power system (common with RF)	11	NSR	1	2	8.1, 8.2
Liquid effluent control system (common with RF)	18, 19, 21	NSR	1	2	11.2.2
Safety-related electrical power system	8,11,22	SR	3	1	8.3
Radiation monitoring system (common with RF)	19,21	NSR	1	2	7b.2, 7b.7.3
Fire detection/suppression system (common with RF)	3	NSR	1	2	9b.3
Other Auxiliary Systems	3	NSR	1	3	9b.7

a) SR = safety-related; NSR = nonsafety-related
b) Safety classification accounts for the highest classification in the system. Systems that are classified as safety-related may include both safety-related and nonsafety-related components. Only safety-related components are used the satisfy the safety functions of the system, whereas nonsafety-related components can be used to perform nonsafety functions.
c) Design criteria 1 – 4 from Table 3.1-1 are not specifically listed but are generally-applicable to all systems. Based on the classification and location of the SSCs, design criteria are applied, as required, using a graded approach as described in the Eden QAPD. The compliance of NSR systems with the generally-applicable design criteria will be further described in the Operating License Application.
d) Nonsafety-related systems without an applicable design criterion are not listed.

Abbreviations: HCF = Hot Cell Facility | PSAR = Preliminary Safety Analysis Report | SCB = steel confinement box(es) | RF = Reactor Facility | HVAC = heating, air conditioning, and ventilation | SSC = structure(s), system(s), and component(s) | QAPD = Quality Assurance Program Description

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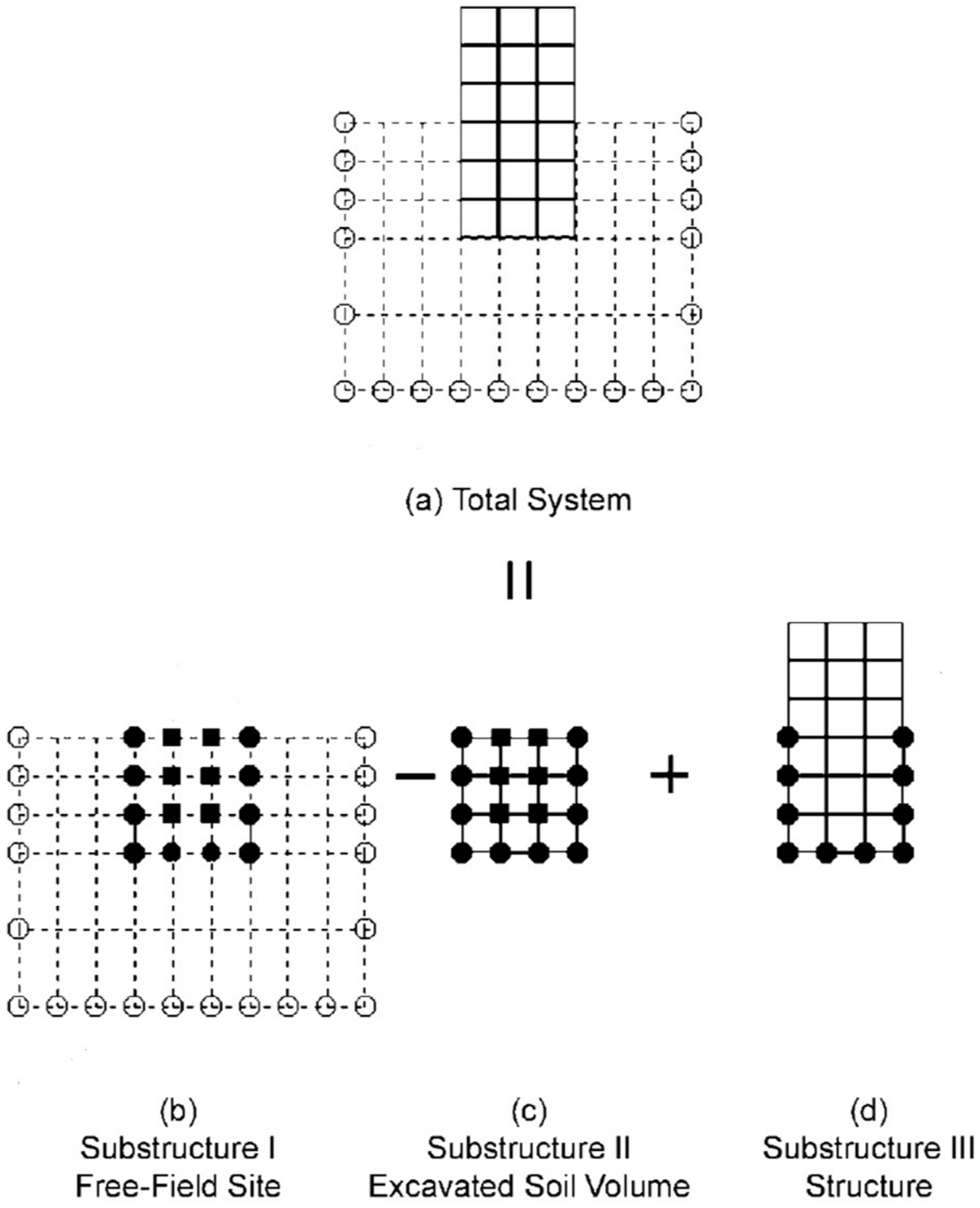
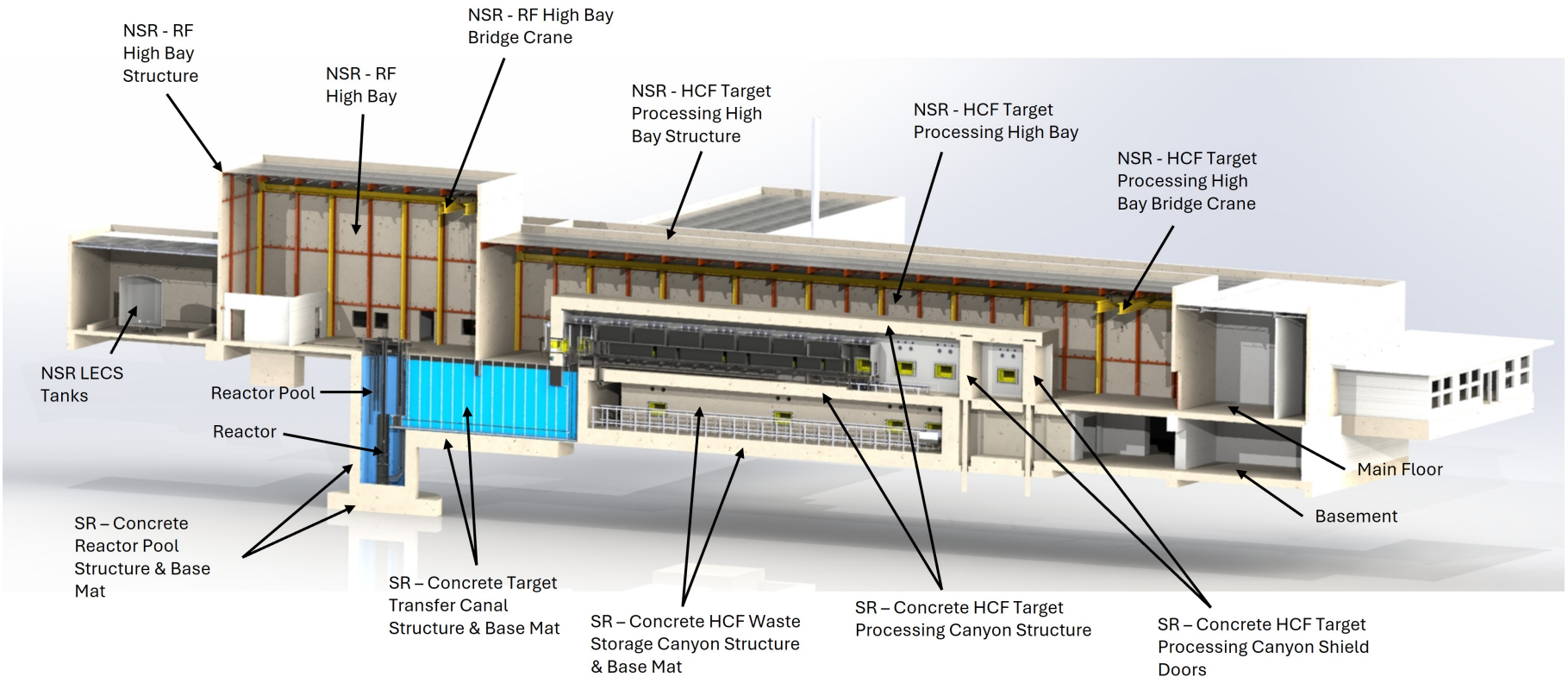
Figure 3.4-1
Substructuring in Direct Flexible Volume Method



Source: SASSI, 2012b.

Figure 3.5-1
Schematic of the EMIF Structure



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Eden Isotope Production Complex
Preliminary Safety Analysis Report

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Revision 0

Chapter 4
Reactor and Radioisotope Production Facility Description

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Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 4a
Reactor Description

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CHAPTER 4a
REACTOR DESCRIPTION

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
α	alpha particle
β	beta particle
β_{eff}	effective delayed neutron fraction
γ	gamma ray
ΔR	reflector thickness
Λ	neutron lifetime
μm	micrometer
°C	degree Celsius
°F	degree Fahrenheit
$	dollar reactivity unit
1-D	one-dimensional
3-D	three-dimensional
Al	aluminum
ANL	Argonne National Laboratory
appm	atom parts per million
Ar	argon
Ar-40	argon-40
Ar-41	argon-41
ATR	Advanced Test Reactor
B	boron
B-10	boron-10
B_4C	boron carbide
Be	beryllium

Acronym/Abbreviation	Definition
Be-8	beryllium-8
Be-9	beryllium-9
cap	neutron capture event(s)
CFR	Code of Federal Regulations
CHF	critical heat flux
CHFR	critical heat flux ratio
Ci	curie
cm	centimeter
cm^2	square centimeter(s)
cm^3	cubic centimeter(s)
DC	design criterion
DOE	Department of Energy
Eden	Eden Radioisotopes, LLC
EMIF	Eden Medical Isotope Facility
ENDF/B-VII	Evaluated Nuclear Data File- version B-VII
ft.	feet
g	gram
gal.	gallon
gpm	gallons per minute
GTRI	Global Threat Reduction Initiative
h	convective heat transfer coefficient
H-2	deuterium
H-3	tritium
HCF	Hot Cell Facility
He	helium

Acronym/Abbreviation	Definition
hr.	hour
I-135	iodine-135
in.	inch
in^2	square inch(es)
in^3	cubic inch(es)
K	Kelvin
k_{eff}	k effective multiplication constant
kg	kilogram
kWt	kilowatt thermal
L	liter
lb.	pound(s)
LEU	low-enriched uranium
Li-6	lithium-6
m	meter
m^3	cubic meter(s)
MASSFLR	Mass Flow Rate [code]
MCHFR	minimum critical heat flux ratio
MCNP	Monte Carlo n-particle
MeV	million electron volts
mg	milligram
mils	thousandths of an inch
Mo-99	molybdenum-99
MPa	megapascal
MW	megawatt(s)
MWt	megawatt thermal

Acronym/Abbreviation	Definition
n	neutron
N-15	nitrogen-15
N-16	nitrogen-16
Ni	nickel
O-16	oxygen-16
ORNL	Oak Ridge National Laboratory
oz.	ounce(s)
p	proton
PSAR	Preliminary Safety Analysis Report
psi	pounds per square inch
psia	pounds per square inch absolute
QAP	Quality Assurance Program
QC	quality control
RF	Reactor Facility
s	second
Sm-149	samarium-149
TRIGA	Training, Research, Isotopes, General Atomics [reactor]
TS	Technical Specification(s)
T_{sat}	saturation temperature
U	uranium
U-235	uranium-235
U-238	uranium-238
UNM	University of New Mexico
U.S.	United States

Acronym/Abbreviation	Definition
W	watt
w/o	weight percent
Xe	xenon
Xe-135	xenon-135
Y-12	Y-12 National Security Complex

4a. Reactor Description

Chapter 4a provides a detailed description of the preliminary design and operation of the all-target, non-power reactor used to produce medical radioisotopes at the Eden Medical Isotope Facility (EMIF). The principal design features, operating characteristics, and parameters of the reactor are described and discussed. The analysis presented in this chapter, along with the analysis in Chapter 13a supports the conclusion that the reactor is conservatively designed for safe operation and shutdown under all credible operating and accident conditions. The information provided in this chapter is used to provide the design bases for many of the systems, subsystems, and functions described elsewhere in this Preliminary Safety Analysis Report (PSAR) and the bases for the probable subjects for Technical Specifications (TS) in Chapter 14a. A more detailed description of the all-target non-power reactor will be provided in the Operating License Application.

The information presented in this chapter represents the baseline reactor configuration design for isotope production. Permutations to the design are also presented to determine their impacts on peaking factors and other nuclear parameters.

The Reactor Facility (RF) portion of the EMIF operates independently from the Hot Cell Facility (HCF). The commonalities between the facilities are the transfer canal, a wall separating the facilities, liquid effluent control system, and common utilities. The RF maintains its own ventilation system and exhaust stack separate from the HCF.

4a.1 SUMMARY DESCRIPTION

The all-target reactor is a steady-state, non-power reactor as defined by NUREG-1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors. The reactor also meets the definition of non-power reactor in Title 10 of the Code of Federal Regulations Part 50, Section 2 (10 CFR 50.2). The reactor is an open-pool type system that uses light water as the moderator and coolant and individual annular low-enriched uranium (LEU) fueled targets. The targets are arranged in a triangular-pitch grid structure within a centrally located hexagonal space within the core shroud that makes up the reactor core. The core is reflected using a beryllium (Be) metal matrix. The target geometry and pitch are optimized to allow for efficient molybdenum-99 (Mo-99) production. The targets are cooled by natural circulation flow. The pool water is cooled using the heat rejection system described in Chapter 5a. The reactor is controlled using control and safety rods located in the core and reflector. The reactor instrumentation and control systems are described in Chapter 7a.

A target consists of a uranium (U) metal foil clad with aluminum (Al) tubing in an annular configuration that allows for cooling on both the inner and outer cladding surfaces. The U foil is LEU with a nominal uranium-235 (U-235) enrichment of 19.75 weight percent (w/o). A thin nickel (Ni) coating, which provides a fission product recoil barrier, is placed on both sides of the U foil to allow for ease in separation when the target is processed in the HCF. The target is designed to operate in a steady-state mode in the reactor.

The goal of the reactor design is to meet or exceed the current United States (U.S.) demand for Mo-99 using the fission process in a highly optimized LEU-fueled reactor geometry. Optimized production requires the reactor to be run in the steady-state mode at a thermal power of 1.8 megawatts (MWt), continuously, with planned periodic short-term (on the order of hours) reactor shutdowns to remove and replace targets for processing. Because the half-life of Mo-99 is 2.75 days, the saturated activity in a target is achieved in about 14 days. Irradiation cycles for the

targets could range from 1 day to 21 days at full reactor power. The limiting condition for the target irradiation duration, from a product purity perspective, is the amount of fission product radionuclides and alpha-emitting radionuclides (actinides) produced from the activation of uranium-238 (U-238) that are found in the Mo-99 product after processing and purification. Typically, target irradiation duration cycles of 7, 14, or 21 days are used. As described in Chapter 4b, targets are processed in the HCF using the modified Cintichem process to separate and purify the Mo-99. The U is recovered in the HCF with separation of the fission products and actinides for waste disposal. The U can then be repurposed and formed into targets under a separate 10 CFR Part 70 license in the HCF target fabrication area, sent back to the U.S. Department of Energy (DOE) as part of the Uranium Lease and Take-Back Program, or disposed of as low-level waste in a once-through cycle.

Eden Radioisotopes, LLC (Eden) plans to process the complete core target inventory every 7, 14, or 21 days to meet the market demand for Mo-99. If demand for Mo-99 is less than the full production capacity of the facility, the irradiation schedule and/or power level can be altered to efficiently match the current demand for Mo-99.

The all-target reactor design contains several features that enhance its safety. These features are as follows:

- Low core fuel mass.
- Low core fission product and actinide inventory.
- Low steady-state power level.
- Low target fuel temperature.
- Passive natural circulation cooling.
- No active shutdown cooling requirements.
- Negative fuel temperature, moderator temperature, and moderator density reactivity feedback.
- No requirements for emergency backup power.
- Simple operation and shutdown features.
- The 60-target core configuration cannot be formed into a critical geometry in water without the Be reflector.

The core is designed to optimize Mo-99 production while minimizing the amount of LEU in the reactor. A U-235 inventory of about [[ ]]^{SRI} is planned for the core. Because the targets are processed every 7, 14, or 21 days, the buildup of long-lived fission products and actinides in the core is minimized. The reactor is a non-power reactor that operates in the steady-state mode at a power level of 1.8 MWt. The targets have a large heat transfer area with the annular cladding cooled on both the inner and outer surfaces. Forced coolant flow is not required through the core. The core uses natural circulation flow established by the coolant density difference from the inlet downcomer and outlet chimney. The large reactor pool provides adequate heat capacity to allow for passive cooling capability with the reactor shut down. The core maintains negative prompt temperature reactivity feedback effects for normal operation and during accident conditions. Because the core is passively cooled during shutdown, no safety-related emergency backup power requirement is needed for cooling the reactor. A loss of electrical power de-energizes the magnet power supply in the reactor

control room, allowing the safety and control rods to decouple and fall by gravity into the core and placing the reactor into a safe shutdown condition. These features allow for simple, well-defined, and characterized operation of the reactor core with minimal risk to the worker, public, and environment.

4a.2 REACTOR CORE

This section describes the major reactor core components, including the targets, neutron moderator, neutron reflector, control rods and drives, safety rod and drive, neutron startup source, in-core cooling components, and in-core irradiation locations.

The baseline reactor is a 60-target core configuration. A target is an annular cylinder that consists of a U metal foil clad on both the inner and outer surfaces with Al-6061 tubing. The U foil is LEU with 19.75 w/o nominal enrichment of U-235. The target inner diameter is 2.20 centimeters (cm) (0.86 inches [in.]) and the outer diameter is 2.56 cm (1.01 in.). The active fuel height is 40.0 cm (15.7 in.). The overall length of the target (without end fittings) is 60 cm (23.6 in.). The targets are designed to operate in a steady-state mode at 30 kilowatts thermal (kWt) average power level. For a 30-kWt average target power, the reactor power level is 1.8 MWt.

With the reactor shut down (i.e., all control and safety rods in the most negative reactivity state, fully inserted position), irradiated targets are removed and replaced with fresh targets in a predefined order and schedule to meet Mo-99 production requirements. One or multiple irradiated targets can be removed and replaced during a weekly shutdown interval. Targets are removed from the core grid using a semi-automated target handling system and placed in a target transfer basket that is part of the target transfer system. The target transfer system is then used to move the irradiated targets to the first processing box in the HCF target processing canyon. Both the target handling system and the target transfer system are described in Chapter 9a. All irradiated target movement is performed underwater. If the target handing system is non-operable, irradiated targets can be handled individually and moved to the target transfer basket using manual target handling equipment. Fresh targets are loaded from the fresh target transfer basket into the core grid using the target handling system or by using a manual target handling tool. Once the core unloading/loading sequence is completed, the reactor is restarted and operated until the next shutdown interval. The loaded irradiated target transfer basket is moved in the underwater transfer canal to the HCF target processing canyon for processing. The transfer can occur with the reactor shut down or operating.

A cutaway view of the reactor core is shown in Figure 4a.2-1 with the major components identified. The core is formed by 60 individual targets arranged in a hexagonal grid (triangular pitch). Each target is positioned in the core by an upper and lower Al-6061 grid plate. The core is reflected using a Be metal matrix positioned within the upper and lower grid plate structure. Reactivity control is provided by four Be-followed boron carbide (B_4C) control rods at the corners of the core within the Be reflector and one Al-followed B_4C safety rod at the center of the target grid. To operate the reactor, the four control rods are driven together as a bank controlling the reactor reactivity, with the safety rod in the fully withdrawn (i.e., most reactive) position. The moderator temperature, moderator voiding, and fuel Doppler broadening effects provide the prompt negative reactivity feedback characteristics of the core.

The core is located near the bottom of a pool in a stainless-steel cylindrical vessel referred to as the reactor pool liner. A bridge structure is supported on the top lip of the pool liner that accommodates the control and safety rod drive mechanisms, the target handling system, and other support equipment. The upper portion of the pool liner and reactor bridge structure is shown in Figure 4a.2-2.

The RF high bay, reactor pool, core, and transfer canal are shown in Figure 4a.2-3.
Table 4a.2-1 provides a summary of the principal reactor design parameters. An elevation view of the reactor pool and core without the bridge structure is shown in Figure 4a.2-4.

A complete description of the reactor pool is presented in Section 4a.3 and the cooling system is described in Chapter 5a. The reactor pool is 3.66 meters (m) (12 feet [ft.]) in diameter and 10.97 m (36 ft.) in depth. The pool liner extends 0.91 m (3 ft.) above the reactor high bay floor. The pool water "filled" level is maintained 0.43 m (1.4 ft.) below the high bay floor level. The top of the core upper grid plate is [[ ]]$^{PROP/ECI}$ below the pool water "filled" level. At this depth the saturated water temperature (T_{sat}) at the core exit is 113 degrees Celsius (°C) (235 degrees Fahrenheit [°F]). The reactor pool (i.e., primary coolant) is deionized water that is maintained using a resin-bed in the reactor coolant cleanup loop described in Chapter 5a. The water provides neutron moderation, target cooling, and radiation shielding during reactor operations and target transfer. The targets are cooled by natural circulation flow through the reactor grid. A chimney extends [[ ]]$^{PROP/ECI}$ from the top of the core grid that allows for a well-established flow path through the reactor core. The reactor pool is cooled using a primary/secondary heat rejection system described in Chapter 5a. The cold-water return line flows into a downcomer that extends to the same level as the chimney, [[ ]]$^{PROP/ECI}$ below the water surface.

4a.2.1 REACTOR FUEL

This subsection describes the targets that are used in the reactor system. Included are the design features that ensure that the U and cladding can withstand all credible environmental and irradiation conditions during their lifecycle in the facility. Handling, transport, and storage of fuel are discussed in Chapter 9a.

Targets are fabricated at a fuel vendor manufacturing facility and/or within the HCF target fabrication area. The targets are fabricated using established procedures and undergo rigorous quality control (QC) inspections as required by the Eden Quality Assurance Program (QAP) during all phases of production. Targets are uniquely identified and marked at the manufacturing facility and are tracked through shipping, storage, irradiation, processing, and waste packaging.

4a.2.1.1 Target Design Basis

The following design criteria (DC) apply to the target design:

- DC 6, Reactor Design: The targets are designed with appropriate margin to ensure that specified acceptable target design limits are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 7, Reactor Inherent Protection: The targets are a key component of the reactor core and are integrated in the core design such that the core maintains prompt negative feedback in the power operating range.
- DC 22, Inspection, Testing, and Maintenance: The targets are designed to provide for adequate inspection and testing to ensure availability and reliability.

The key design basis for the all-target reactor is to produce the highest quantity of Mo-99 with the smallest amount of LEU fuel, maximizing the target power level and minimizing the reactor size. At a reactor power level of 1.8 MWt, the current U.S. demand for Mo-99 can be met if half of the core (30 targets) is processed every week. This results in a 14-day irradiation cycle for the targets. If the production demand is less than the current U.S. demand, other cycles can be considered. For 66 percent of the current U.S. demand, one-third of the core (20 targets) would be processed every week on a 21-day cycle. For lower demands, the reactor would be operated

at a lower power level with more targets processed per week. Target burn-up is limited to 0.75 megawatt (MW)-days, equivalent to an average target power of 30 kWt irradiated for 25 days.

An annular target design is used for the following reasons:

- It allows for cooling on both the inner and outer surfaces of the target, maximizing the heat transfer area.
- Thin LEU metal foils can be incorporated into the target design, minimizing the fuel mass per heat transfer area and minimizing the fuel temperature.
- The DOE isotope program has invested significant research in developing LEU metal foil production techniques.

Optimizing the target diameter, fuel length, and LEU foil thickness involves design iterations using neutronics analysis, heat transfer analysis, and thermal-hydraulic analysis. The fundamental fuel design characteristics include a high heat transfer capability, low fuel temperatures, a large prompt negative reactivity feedback effect, and mechanical resilience. Intimate contact between the fuel foil and the cladding during the irradiation cycle is required and must be factored into the target manufacturing process. Well-controlled tolerances on the foil fuel mass, foil thickness, foil thickness uniformity, foil length, fuel impurities, Al cladding thickness uniformity, and Al cladding impurities are required to ensure that the target manufacturing is well-controlled and that all targets are fabricated and function identically and as designed. QC inspections and Quality Assurance documentation processes are adhered to during all phases of the target manufacturing process in accordance with the requirements of the Eden QAP.

The target mechanical design is dominated by the criterion that the integrity of the primary containment for fission products (i.e., fuel matrix and cladding) be maintained for all normal operations during the irradiation cycle. Assuming that no cladding defects are present after manufacturing, failure of the fuel/cladding during reactor operation could occur by four mechanisms, discussed further in Chapter 13a:

- A fuel foil/cladding gap that formed during the manufacturing process was not detected during inspection.
- A fuel foil/cladding gap that formed during fresh target storage, transfer, or handling was not detected during inspection.
- A fuel foil/cladding gap formed during full-power operation by the generation of internal pressure or degradation of the cladding material properties.
- The critical heat flux (CHF) for a target was exceeded during operation.

The main objective in selecting the target design is to obtain a heterogeneous fuel system that provides a high degree of operational safety regardless of equipment malfunction or human error. Nuclear performance objectives dictate that the fuel have favorable (desirable) neutronic characteristics including a prompt negative temperature coefficient to offset the effects of sudden power excursions resulting from large positive reactivity insertions. Desirable physical properties for the targets include adequate strength and form stability, good thermal conductivity, and chemical stability. Another desirable property is high fission product gas retention within the fuel foil matrix. The purpose of the thin Ni recoil barrier between the fuel foil and the Al cladding is to ensure that fission fragments are stopped in the Ni, preventing bonding

between the U foil and the cladding and ensuring that the fuel foil can be easily removed from the cladding during Mo-99 processing.

The primary criteria in the selection of the target cladding material are the effective containment of the fission products that escape the fuel matrix and the maintenance of good mechanical properties, such as tensile strength, ductility, impact strength, and creep, throughout the target lifecycle. Throughout the life of the target, the cladding structural integrity must survive temperature cycling, temperature excursions, neutron and gamma irradiation, and external abrasion without degradation. Thus, the yield and ultimate tensile strength of the cladding material at operating temperatures and irradiation exposures are criteria for selection, as are the available fabrication methods and techniques for ensuring a mechanical contact between the fuel foil, Ni recoil barrier, and the cladding, and leak-tightness of the cladding. The target cladding must also have a minimal corrosion rate in the highly pure, deionized water environment. For these reasons Al-6061 was chosen as the cladding material.

4a.2.1.2 Target Design Description

A target consists of a U metal foil approximately [[ ]]$^{PROP/ECI/SRI}$ in thickness, coated on both the inner and outer surfaces by a thin Ni layer, and clad on both surfaces with Al-6061 tubing. The U foil is LEU with 19.75 w/o nominal enrichment of U-235. The U foil and Ni recoil barrier are compressed between the Al cladding. The thin Ni coating is placed on both sides of the U foil to allow for ease in separation when the target is processed in the HCF. Without the Ni recoil barrier, the U foil could bond to the Al cladding when fission fragments impinge directly onto the cladding. The target inner diameter is 2.20 cm (0.86 in.) and the outer diameter is 2.56 cm (1.01 in.). The active fuel height is 40.0 cm (15.7 in.). The overall length of the target (without end fittings) is 60 cm (23.6 in.). The typical target contains [[

]]$^{PROP/ECI/SRI}$ in thickness.

A fully assembled target consists of the annular target and the fixturing hardware that allows for transfer and loading of the target into and out of the reactor core. The target, without the hardware, is shown in Figure 4a.2-5 and dimensions are presented in Table 4a.2-2. At the HCF, the targets are removed from their shipping container (if the targets are manufactured by an off-site fuel vender), visually inspected, and prepared for use by attaching the fixturing hardware. The targets are logged using a unique numbering system. Every target has a unique identifying number indelibly placed on the outer cladding during the manufacturing process.

The target design and U foil fabrication techniques have been developed and tested over several decades for the DOE isotope production program by Argonne National Laboratory (ANL) and Y-12 National Security Complex (Y-12) as part of the Global Threat Reduction Initiative (GTRI) (Vandegrift, 2016). Recently, through the DOE Mo-99 Work Package program, Y-12 has developed techniques for casting LEU ingots and forming U foils that meet Eden's target specifications. The starting material for the targets is LEU metal ingots that have been assayed for U isotope and impurity content. The U composition used in the neutronic analysis is shown in Table 4a.2-3. The neutronic analysis will be updated in the Operating License Application if the U composition, including alloys and impurities in Table 4a.2-3, is not bounding.

The targets are fabricated in the following sequence:

- LEU metal ingots are cast with the prescribed alloy content.

- LEU metal ingots are heated and rolled into foils of the correct thickness, mass, and dimensions.
- Foils are heat treated using a beta quench, alpha anneal process.
- QC inspections are performed on the foils.
- Foils are cut to the proper dimensions.
- Ni recoil barrier coating is applied to both surfaces of the foil.
- Foils are cylindrically shaped with the specified diameter.
- A cylindrically shaped foil is centered within the outer Al cladding and the inner Al cladding is placed within.
- The target is hydroformed from the inside of the inner cladding using hydraulic manufacturing techniques.
- The formed target is cut to the correct overall dimensions and the inner and outer cladding are welded together at each end.
- QC inspections are performed on the final target.
- The target is uniquely identified, marked, and logged.
- The target is complete and ready for shipment or storage.

Tolerances for the U foil, Ni recoil barrier coating, and Al-6061 cladding, including the acceptance criteria for the completed target, will be presented in the Operating License Application.

4a.2.1.3 Target Handing Fixture Description

A target is an annular cylinder 60 cm (23.62 in.) in length. A target is required to be fitted manually with hardware to form a target assembly that can be handled and transferred in the pool and loaded in the core grid. Figure 4a.2-6 shows the target with the fixturing hardware. The hardware is fabricated from Al-6061 and is made up of three pieces; a lower tri-flute fixture, an upper tri-flute fixture, and a center solid rod. The three pieces are assembled and joined together with fasteners on the centering rod. The upper flute fixture has a special top fitting for securing the target handling tool.

The purpose of the centering rod includes the following:

- It allows the upper and lower flute fixtures to be secured to the target.
- It allows for a void region to be within the target for optimized neutronic water moderation conditions.
- It serves to balance the coolant flow area between the inside and the outside of the target.

Once the fixturing hardware is assembled on the target, the completed target is ready for use. As described in Chapter 4b, after irradiation, the targets are transferred, via the transfer canal, to the first processing box in the HCF target processing canyon, called the target receipt box. Within the shielded target receipt box, the flute fixtures and centering rod are remotely removed from the target and are available for reuse on future targets. The fixtures and rod are inspected prior to reuse to ensure that there is no damage to the hardware.

The target heated surface area is [[

]]PROP/ECI/SRI

4a.2.1.4 Target Tests, Inspections, and Operational Requirements

Annular target fabrication, testing, and processing have been a priority for the GTRI program for several decades. Before 2012, all LEU target and process development was performed at ANL. At the end of 2012, the GTRI formulated a new strategy for increasing the technical readiness of the annular LEU-foil target and front-end processing to allow its use by Mo-99 producers. This effort was led by Y-12 in partnership with ANL, Oak Ridge National Laboratory (ORNL), the University of Missouri Mechanical Engineering Department, and the University of Missouri Research Reactor (Vandegrift, 2016). This new plan, supported by the National Nuclear Security Administration, has allowed for a significant increase in the technology readiness for the fabrication, irradiation, and processing of LEU annular targets.

The LEU High Density Target Project successfully demonstrated several iterations of a LEU fission-based Mo-99 technology. Over 50 annular high-density targets were successfully fabricated, with the assembly and disassembly of targets improved and optimized. This project allowed for the development of a new target processing methodology in which the chemical processing of the targets is greatly simplified.

The state of the target manufacturing development has a large enough technological readiness to allow for consideration in the all-target reactor concept. However, to advance the technology to a point where high-quality targets can be routinely produced such that 30 targets per week can be irradiated and processed, development work has been ongoing at the Eden Laboratory, Y-12, Los Alamos National Laboratory Sigma Facility, and ORNL. The effort at the national laboratories over the last several years has been supported by the DOE and has focused on casting U ingots, U foil fabrication, Ni coating techniques, and target assembly using Al-6061 cladding.

Eden has developed hydroforming technology that allows for target assembly using U foils and standard Al-6061 tubing readily available from commercial vendors. This hydroforming technology allows for the fabrication of a target that maintains high heat transfer properties from the U foil to the coolant. The foil is securely bound between the Al-6061 cladding after hydroforming, with the [[ ]]PROP/ECI
The hydroforming technology also provides a unique pressure versus time signature during fabrication, that is used as a QC measure, ensuring the target was properly hydroformed. Eden has also developed a measuring technique to determine the thermal diffusivity of the hydroformed target, ensuring adequate contact between the U foil and the cladding.

As described in Chapter 1, a Target Qualification Program has been developed by Eden. The goal of the Target Qualification Program is to provide assurance that the targets can be manufactured and safely irradiated at full-power operation for the duration of their lifecycle. The results of the Target Qualification Program will be fully described in the Operating License Application.

4a.2.2 CONTROL AND SAFETY RODS

This subsection describes the control and safety rods and the associated rod drive mechanisms that control their movement in the core. A description of how the rods and drives function with the control console is presented in Chapter 7a. The expected worth of the control and safety rods and their position in the core is described in Subsection 4a.5.3.2.

4a.2.2.1 Control and Safety Rod Design Basis

The following DCs apply to the control and safety rod design:

- DC 6, Reactor Design: The control and safety rods are designed such that the reactor can be operated and shut down with appropriate margin to ensure target design limits are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 13, Protection System Functions, Reliability, Testability, Independence, and Failure Modes: The control and safety rods are designed with appropriate reactivity values such that the reactor can be safely shutdown with margin during normal operating conditions, anticipated operational occurrences, and accident conditions. Additionally, the control and safety rods design ensures the ability to rapidly insert negative reactivity via gravity-fall to maintain fuel design limits.
- DC 14, Combined Reactivity Control Systems Capability, Reactivity Limits, and Protection Against Anticipated Operational Occurrences: The control and safety rods are designed to have a combined capability of reliably controlling reactivity changes to ensure that, under accident conditions with appropriate margin for the maximum worth stuck rod, acceptable target design limits are not exceeded. The control and safety rods are designed, with margin for a maximum worth stuck rod to maintain the reactor core subcritical under cold, clean conditions.
- DC 22, Inspection, Testing, and Maintenance: The control and safety rods are designed for adequate inspection, testing, and maintenance to ensure availability and reliability to perform the required safety functions.

Two types of reactivity-regulating rods are required to operate the reactor. These rods are identified as a safety rod and control rods. The reactor design has four identical control rods and one safety rod. The design basis for the control rods and safety rod is the same. They are all designed to have a poison section that is in the core region during shutdown and a follower section that enters the core as the rod is withdrawn. The follower section is a Be element for a control rod and an Al element for the safety rod. The rods are designed to be easily moved in a full vertical stroke within a specified location in the core between the upper and lower grid plates. The control rods are designed to have sufficient reactivity worth to operate the reactor from a clean-cold critical condition to full power. The safety rod is designed to have sufficient reactivity worth to maintain a negative reactivity shutdown margin and to satisfy the stuck rod criterion. The four control rods are operated as a bank to control the reactivity of the reactor during normal operations.

The safety rod system has sufficient reactivity to allow for an adequate shutdown margin to be maintained. The system is designed to be capable of rapidly inserting negative reactivity into the core if a reactor scram or trip occurs or in the event of a loss of electrical power. The safety rod

is fully withdrawn (i.e., full-up position) from the core during steady-state operations. The safety rod is located in the center grid position in the core.

The control rod system has sufficient reactivity worth to enable the reactor to operate at prescribed power levels, up to 1.8 MWt, by overcoming negative temperature reactivity effects, fission product poisoning reactivity effects, and fuel burnup reactivity effects. The system is designed to be mechanically stable, is capable of precise positioning, and provides rapid insertion of negative reactivity into the core if a reactor scram or trip occurs or in the event of a loss of electrical power. The four control rods are located at four corner locations in the Be reflector matrix. This arrangement allows the poison to be distributed throughout the core during normal operation.

Design considerations for selecting materials for the control rods and safety rod are as follows:

- The ability to withstand the static and dynamic loads of steady-state operation without failure or fatigue upon repetition of the loadings throughout the expected life of the components.
- Resistance to degradation in function due to corrosion in the water coolant, humidity above the pool, and radiation environment.
- Resistance to degradation in function due to wear and to servicing procedures.

4a.2.2.2 Control and Safety Rod Design Description

Figure 4a.2-7 shows the design of the control rods and safety rod. Each rod contains a neutron absorber section and a reflector follower section. The neutron absorber material is enriched boron (B) in the form of B_4C. The B_4C is in the form of solid pellets approximately 2.6 cm (1.02 in.) in diameter stacked to a height of 60.0 cm (23.6 in.) or less within an Al-6061 cylindrical liner. The absorber length is such that the absorber covers the entire active fuel height when the rod is fully inserted (i.e., full-down position) in the core. The B_4C pellets and Al-6061 liner are enclosed in an Al-6061 welded cladding. A void section approximately 15 cm (5.9 in.) in length exists above the poison section to collect helium (He) that is produced in the B_4C and escapes the pellets. The cladding is sealed on the bottom end with a welded plug. The upper plug is part of a spacer that secures the B_4C pellets in place. The upper cladding plug maintains a fixture for handling and a through-hole for backfilling the poison section and the void space with He. Each rod is backfilled with approximately 0.2 megapascal (MPa) (29.4 pounds per square inch absolute [psia]) of He, sealed during the manufacturing process, and leak tested.

The absorber section of the rod is followed by a solid Be cylindrical element for the control rod, and a solid Al cylindrical element for the safety rod. The reflector follower provides an enhancement in the reactivity worth of a control rod. The follower section is attached to the poison section. The rod assembly is approximately 160 cm (63.0 in.) in length and approximately 3.0 cm (1.18 in.) in outer diameter.

The control and safety rod design is different from traditional open pool reactor designs to allow access to the top of the core for target changeout. The design of the rod drive system incorporates features to move the control/safety rods from beneath the core. As shown in Figure 4a.2-8, the bottom of each control and safety rod is connected to the drive mechanism located on the bridge structure by a connecting rod through an electromagnetic coupling. Each connecting rod is offset to the associated control and safety rod. At the full down position, the control/safety rods are inserted and the reactor is shutdown. For reactor operation, the

control/safety rod is withdrawn by raising the connecting rods and, thus, the control/safety rods. The electromagnetic coupling provides for the gravity-fall insertion of the rod into the core in the event of a reactor scram or trip, or loss of electrical power. The connecting rod is Al-6061, approximately 10 m (32.8 ft.) in length, with an iron base armature for magnetic coupling.

Each of the four control rods and the safety rod is independently driven and positioned by an electric motor drive system. Although all four control rods may be driven simultaneously as a bank, they are all operated by independent drive mechanisms. The drive mechanisms for all the rods are the same. The rods are guided into and out of the reactor core by holes in the upper and lower grid plates. The control and safety rods' full-down operating position (i.e., shutdown position) is established by the lower positive mechanical stop in the rod drive assembly. If the stop were removed, the rods could fall only a short distance before coming to rest on the bottom plate of the guide tube. Hence the poison section would remain in the core fuel region with the stops removed.

The rod drive mechanism is shown in Figure 4a.2-9 and is discussed in detail in Chapter 7a. The rod drive mechanisms for the control rods and safety rod are all identical. The motor actuates a travel ball screw to drive the rod vertically into or out of the core. The moving parts of the drive mechanism are fully enclosed and mount to the bridge structure above the reactor pool. Rod directional motion is controlled by voltage polarity received by the motor from the control console. The motion of the ball screw drive is transmitted through a thrust tube that attaches to the connecting rod armature via an electromagnet. The electromagnet also maintains a proximity switch to indicate coupling of the electromagnet to the armature. Below the armature on the connecting rod is a piston that travels in a guide tube. The tube terminates with a mechanical stop for the piston that limits the downward travel of the control rod. The guide tube is partially submerged in the water. With the rod fully inserted (i.e., full-down position), the connecting rod armature remains above the waterline. The guide tube also acts as a dashpot via graded water vents to progressively retard the downward rod motion, minimizing the impact shock as the piston strikes the lower stop. Limit switches define the travel range by stopping the drive motor at upper and lower limits. This is performed by interlock functions at the control console.

The electromagnetic coupling serves to provide instantaneous disengagement of the control or safety rod from the drive mechanism upon de-energizing. Thus, interruption of the electric current for any reason results in gravity-fall of the rod to the full-down position (i.e., shutdown). The amount of time required for de-energizing and complete insertion is expected to be less than 0.5 seconds (s). The drive assembly is mounted on a plate attached to the bridge. The speed that the motor can be driven is set by a voltage controller in the control console.

Because the control rods and safety rod remain in their guide holes in the upper and lower grid plates during their full stroke, and a guide tube maintains the geometry of each rod below the lower grid plate, sticking or binding of a rod due to misalignment is prevented. In addition, the guide holes and tubes have a nominal diametrical clearance so that sticking or binding of the rods in the core is effectively precluded.

Because the reactor core is cooled by natural circulation flow, the pressure forces associated with coolant flow through the core are small. Thus, the coolant forces available to induce displacement and/or oscillation of control rods, the safety rod, or targets are negligible. As noted above, failure of the lower mechanical stops in the rod drive mechanism results in a rod drop of only a short distance below the core. This distance is limited and prevents any reactivity

anomaly. Thermal expansion of any of the components in the reactivity control system has a negligible effect on reactivity.

4a.2.3 NEUTRON MODERATOR AND REFLECTOR

The neutron moderator for the all-target reactor core is water. The same water is also the coolant for the targets and the reflector and provides biological shielding.

The reflector for the all-target reactor core is Be metal. Be is the design option chosen because it exhibits significant neutron reflection properties, has high thermal conductivity properties at room temperature, and has been successfully used in many test and research-type reactors. No other reflector materials allow for the equivalent amount of reflector savings and associated small reactor size.

The form for the Be metal reflector is in the shape of a hexagon matrix as shown in Figure 4a.2-10. This form allows for regular shapes to be fabricated within tolerances. Six of these forms make up the complete hexagonal shaped reflector. The six shapes fit on the lower grid structure of the core using an Al lower reflector support. An Al upper reflector support maintains the reflector geometry to the top grid plate (not shown in the figure). The Be matrix is cooled on the front faces by the natural circulation of water coolant flow past the targets, and on the back faces by the water coolant that is directed by flow ports located in the lower and upper grid plates as shown in Figure 4a.2-8. The flat-to-flat dimension for the hexagonal reflector shape is [[ ]]$^{PROP/ECI}$. The reflector thickness (ΔR) is approximately [[ ]]$^{PROP/ECI}$. The reflector height is [[ ]]$^{PROP/ECI}$ and is centered at the axial target centerline.

Neutronic and heat transfer calculations show that the radiation damage and the direct neutron and gamma-ray heating of the reflector are within acceptable limits.

4a.2.4 NEUTRON STARTUP SOURCE

A neutron source is required at reactor startup to ensure that an adequate number of neutrons exist in the reactor core to preclude a source-less startup condition. The neutron source is a standard Be-type encapsulated source provided by the source manufacturer. The encapsulation materials allow for continuous immersion in water. The “inserted” position of the source is in a corner position of the core.

The source is part of the source drive mechanism. The source is moved within an Al guide tube that extends below the core structure. The source is moved into and out of the core using an extension rod and an electrical motor-controlled drive mechanism similar to a control rod drive mechanism. The source movement is controlled at the reactor console for insertion or removal.

Once the critical condition is established, the source is removed from the reactor by the mechanical system to approximately 1 m (39 in.) below the core to ensure that the source is not “burned up” by an extended period of high neutron flux. Features described in Chapter 7a prevent the reactor from being operated without a sufficient source of neutrons present.

Once irradiation has been experienced by the targets in the core, an inherent photoneutron source exists in the core, as described in Subsection 4a.5.3.12. When this occurs, the startup source may or may not be required, depending on the intrinsic neutron source strength at the time of startup.

4a.2.5 CORE SUPPORT STRUCTURE

The core support structure for the all-target reactor is shown in Figure 4a.2-11. The purpose of the core support structure is to provide and maintain the integrity and configuration of the core and other hardware and instrumentation required for continuous operation of the reactor at full power in a safe and reliable manner. The core support structure maintains the geometry for targets, reflector matrix, control and safety rod guides, and the neutron source rod guide. The core support structure is made up of the following components:

- Lower support structure and plenum.
- Lower grid plate.
- Upper grid plate.
- Core shroud.
- Control and safety rod guides.
- Chimney and downcomer.
- Instrumentation mounting hardware for mounting neutron detectors.
- Neutron source guide.

All the components of the core support structure are fabricated from Al-6061.

The lower support structure maintains a base plate that attaches to the floor of the reactor pool liner. The lower support structure is also made up of a lower plenum that is cylindrical and welded to the base plate. The diameter of the lower plenum is approximately [[ ]]$^{PROP/ECI}$. It has an inlet port where the downcomer is attached. The downcomer extends from the lower plenum to the same height as the chimney, as shown in Figure 4a.2-4. The diameter of the downcomer is approximately [[ ]]$^{PROP/ECI}$. The coolant water return line outlet (i.e., cold water) discharges directly into the downcomer inlet.

The lower grid plate is [[ ]]$^{PROP/ECI}$ thick and is fastened to the top flange of the lower plenum. It maintains the holes required for coolant flow and positioning the targets, and reflector matrix support. Guide tubes extend from the lower grid plate to the lower guide tube alignment plate to allow for accurate alignment of the control and safety rods.

The core shroud is a cylinder with the same diameter as the lower plenum and maintains a flange on each end. Its lower flange is attached to the lower grid plate.

The upper grid plate is [[ ]]$^{PROP/ECI}$ thick and is fastened to the upper flange of the core shroud. It maintains the same hole locations as the lower grid plate. The locations for the targets are pass-through bore holes that allow the targets to be inserted into the lower grid plate.

The chimney is a [[ ]]$^{PROP/ECI}$. It maintains a flange on its lower end that allows it to be attached to the upper grid plate.

An instrumentation rack (not shown in the figure) is attached to the upper flange of the lower plenum. The instrumentation rack holds the neutron and gamma-ray detectors and any other instrumentation required for operation and control of the reactor.

There are no connections or solid structures from the core support structure to the bridge structure. The core support structure is a completely standalone fixture that is fixed to the bottom of the reactor pool liner. The control rods, safety rod, and neutron source have connecting rods and guide tubes that are aligned for operation from the bridge structure.

Table 4a.2-1
Summary of Reactor Design Parameters

Reactor type	Pool type, steady state, non-power reactor
Moderator/coolant	Deionized water
Reflector	Be metal
Pitch	Triangular
Target cooling	Natural circulation flow
Pool cooling	Primary/secondary heat exchanger
Type of fuel	Annular targets
Fuel material	U metal foil with Ni recoil barrier
Fuel enrichment	LEU (19.75 w/o U-235)
Cladding	Al-6061 inner and outer
Core size	60 targets (baseline core)
Target cycle	1 day to 21 days 7 days, 14 days, or 21 days (typical)
Individual target power	30 kWt average
Total reactor power – thermal	1.8 MWt (baseline core with 60 targets)

Abbreviations: Be = beryllium | U = uranium | Ni = nickel | LEU = low-enriched uranium | U-235 = uranium-235 | Al = aluminum | kWt = kilowatt-thermal | MWt = megawatt- thermal

Table 4a.2-2
Target Nominal Dimensions

Target inner diameter		2.20 cm
Target outer diameter		2.56 cm
Fuel length		40.0 cm
Total target length		60.0 cm
Al cladding thickness		0.08 cm
Ni recoil barrier thickness	[[	]]PROP/ECI/SRI
U metal foil thickness	[[	]]PROP/ECI/SRI
U metal foil volume	[[	]]PROP/ECI/SRI

Abbreviations: cm = centimeter(s) | Al = aluminum | Ni = nickel | U = uranium | cm^3 = cubic centimeter(s)

Table 4a.2-3
Uranium Isotopic Composition Used in Neutronic Analysis

Nuclide	Weight Percent of U
U-234	0.217
U-235	19.750
U-236	0.00
U-238	80.033
Total U	100.00

Abbreviations: U = uranium | U-## = isotope of uranium
Note: These compositions were used for neutronic modeling – actual composition may be different.

4a.3 REACTOR POOL

The reactor pool is in the central area in the RF high bay. The layout of the reactor, pool cooling lines, and transfer canal is shown in Figures 4a.3-1 and 4a.3-2. The all-target reactor is operated in an in-ground open pool that allows for several key design features to be incorporated into the design basis. Major features of the open pool design include the following:

- Radiation shield.
- Thermal mass.
- Fission product retention.
- Ease of reactor operation.
- Ease of target transfer.

The following DCs apply to the reactor pool:

- DC 9, Reactor Coolant Boundary: The concrete foundation walls, base mats and liner for the reactor pool and transfer canal shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, or of gross rupture. These features shall be designed with sufficient margin to ensure that the design conditions of the reactor coolant boundary are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 16, Heat Removal: The reactor pool has sufficient heat capacity to remove residual heat with sufficient margin to ensure that the design conditions of the reactor are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The reactor pool and transfer canal have sufficient holdup capacity for retention of soluble radionuclides including the halogen fission products during normal operation, anticipated operational occurrences, and accident conditions.
- DC 22, Inspection, Testing, and Maintenance: The design of the safety-related portions of the pool structure provide adequate inspection, testing, and maintenance to ensure availability and reliability to perform the required safety functions.
- DC 23, Biological shielding: The concrete pool structure and liner, transfer canal structure and liner, and pool water are designed to provide shielding to protect the workers from unacceptable levels of radiation during normal operation, anticipated operational occurrences, and accident conditions.

The concrete foundation walls and base mats for the reactor pool and transfer canal are safety-related systems, structures, and components.

Figure 4a.3-1 shows an elevation view of the pool depicting the cooling lines and materials that make up the pool structure. Figure 4a.3-2 shows a 90 degree rotation elevation view depicting the transfer canal and the dimensions of the pool. The pool liner design consists of a single stainless-steel vessel encased in concrete. The liner is 0.635 cm (0.25 in.) thick. The liner also includes the attached (welded) transfer canal. The liner has a stainless-steel bottom plate of the same thickness welded to the liner.

A concrete footing forms the base for the pool liner. With the liner installed, a concrete form is placed between the fill material and the liner. The liner is 3.66 m (12 ft.) in diameter and extends 10.06 m (33 ft.) below floor level and 0.91 m (3 ft.) above floor level. The pool water “filled” level is kept just below floor level, approximately 0.43 m (1.4 ft.) below the floor surface. A bridge structure (not shown in the figures) that maintains the control and safety rod drives, other control mechanisms, and the target handling system is secured on the top of the liner flange. There are no openings through the liner wall below the water line except for the transfer canal.

The large amount of water and the depth of the pool allow for an inherent radiation shield for the protection of the worker during full-power operations, shutdown, and irradiated target transfer. The radiation shielding effectiveness is described in Section 4a.4. The large volume of the pool, approximately 101,000 liters (L) (26,700 gallons [gal.]) of water, excluding the volume in the transfer canal, allows for a large thermal mass during both full-power operations and decay heat removal during shutdown. The pool heat-up rate when operating at 1.8 MWt without pool cooling is 0.0043°C (0.0077°F) per s, 0.254°C (0.457°F) per minute, or 15.3°C (27.5°F) per hour (hr.). Assuming a core decay power of 35 kWt (1.95 percent of full power at 10 minutes after reactor shutdown), the pool heat-up rate is 0.3°C (0.54°F) per hr. There is no requirement for the reactor coolant system to be operating during shutdown.

The large volume of water also allows for significant retention of activation products in the water or any fission products or actinides that might be released into the water from the targets under accident or abnormal conditions. The open pool also allows for ease in the design and operation of the reactor and ancillary systems. Simple mechanisms are used to operate control and safety rods. Transfer of fresh and irradiated targets into and out of the core and into the transfer canal is efficiently performed with the large open pool.

The transfer canal liner is connected to the pool liner 5.06 m (16.6 ft.) below the pool “filled” level. The only other pool liner opening is near the high bay floor level, significantly above the reactor core, above the water level. This single opening includes the water inlet and outlet to the cooling system and the cleanup and makeup water lines. There are no openings below the connection of the transfer canal liner, which significantly decreases the likelihood of any type of leak of the primary coolant water and diminishes the probability of a catastrophic failure of the pool structure.

The transfer canal, which is considered to be part of the pool, is approximately 40 cm (15.7 in.) in width and approximately 5.06 m (16.6 ft.) deep from the pool filled level. The transfer canal extends from the reactor pool, through the separation wall into the first processing box of the HCF target processing canyon, approximately 12.5 m (41.0 ft.) in length. The stainless-steel transfer canal liner is welded to the pool liner. The target transfer basket is moved laterally from the HCF into the reactor pool using a transfer system described in Chapter 9a. A window on the inner stainless-steel liner allows the target transfer basket to be moved into the reactor pool. The depth of the transfer canal allows for expedient transfer of the irradiated targets into the target transfer basket and provides adequate radiation shielding for the worker during transfer operations.

The volume of the pool is approximately 101,000 L (26,700 gal.) of water. The volume of the transfer canal is approximately 25,300 L (6700 gal.) of water. The total volume of the pool and transfer canal is approximately 126,300 L (33,400 gal.) of water.

4a.4 BIOLOGICAL SHIELD

The water in the reactor pool and the transfer canal is the primary biological shield in the RF. It protects the worker from high levels of radiation from the reactor during both steady-state, full-power operations and during shutdown. The water in the pool and transfer canal limits the radiation levels during irradiated target transfer to the HCF. The water also acts as a barrier to attenuate the release of activation isotopes, such as nitrogen-16 (N-16), argon-41 (Ar-41), and tritium (H-3), that are created by neutron activation in the water. The water also retains fission products and actinides and limits their release to the high bay in the event of a leak or failure of the target cladding.

The water height above the core at the filled level is [[ ]]$^{PROP/ECI}$. The water depth protects the worker from direct neutron and gamma-ray radiation emitted from the reactor core during full-power steady-state operations and direct gamma-ray radiation from fission product decay during shutdown. The transfer canal allows for at least 4.3 m (14 ft.) of water height above the target transfer basket in the transfer canal, protecting the worker from direct gamma-ray radiation emitted from the irradiated targets due to fission product decay.

Radiation levels at the reactor bridge directly above the reactor are less than 10 milli-Roentgen/hr from direct radiation and N-16 decay when the reactor is operating at 1.8 MWt. Area radiation monitors and continuous air monitors are positioned at various locations in the facility with local alarms and alarms at the reactor control console. The RF high bay is not continuously occupied during reactor operations. Access to the high bay is controlled by reactor operations personnel.

4a.5 NUCLEAR DESIGN

This section describes the nuclear parameters and characteristics of the all-target reactor core.

The results of the neutronic analysis for the baseline core design are presented. The results include the core configuration excess reactivity, control and safety rod reactivity worth, fuel temperature reactivity feedback, core moderator temperature and density feedback, reflector temperature feedback, fission product poisoning and fuel burnup reactivity effects, target axial peaking factor, and target-to-target average peaking factor. Other neutronic parameters calculated include the neutron lifetime and the effective delayed neutron fraction, β_{eff}. Other neutronic calculations performed related to safety include analysis of a missing target and a misloaded target to determine the effects on nuclear and thermal hydraulic parameters. Other results include He production in the reflector matrix and control rods, neutron and gamma-ray heating of the reflector matrix and control rods, and Ar-41, N-16, and H-3 production in the water moderator.

The baseline/limiting reactor core configuration is presented in this analysis. The configuration represents a baseline point design that is representative of a full production scenario that is capable of meeting or exceeding the current U.S. demand for Mo-99. The steady-state operating power level for the baseline configuration is 1.8 MWt.

The nuclear design for the all-target reactor core baseline is derived from a series of parametric neutronic analyses resulting in an optimized configuration that safely produces the most Mo-99 product for a given fuel mass. The objective of the all-target reactor is to process all the targets in the core on a 7, 14, or 21-day cycle, thereby minimizing the amount of fuel used in the isotope production process.

4a.5.1 NUCLEAR DESIGN BASIS

The following DCs apply to the reactor nuclear design:

- DC 6, Reactor Design: The nuclear design of the all-target reactor incorporates appropriate margin to ensure that the specified target acceptable design limits are not exceeded during normal operation, anticipated operational occurrences, and accident conditions. The nuclear design incorporates, in the design of the targets, reflector, and control and safety rods, features so that startup, operation, and shutdown reactivity margins are maintained.
- DC 7, Reactor Inherent Protection: The all-target reactor core is designed to maintain prompt inherent negative reactivity feedback characteristics during normal operation and anticipated operational occurrences.

4a.5.2 NORMAL OPERATING CONDITIONS

This subsection presents the nuclear design description and the analytical tools and methods used to perform neutronic analysis for the baseline core configuration.

4a.5.2.1 Nuclear Design Description

The reactor core is made up of the LEU targets, Be reflector matrix, control and safety rods, a grid structure, and a core support structure. The core lattice design is based on a neutronically optimized triangular pitch that is fixed by the design of both the upper and lower grid plates. The

pitch is the center-to-center spacing of the targets in the core lattice. Key dimensions, including the pitch and flow channel area for the targets, are shown in Figure 4a.5-1.

The pitch is 3.08 cm (1.21 in.) and is fixed by the design of both the upper and lower grid plates. The target outer diameter is 2.56 cm (1.01 in.), the pitch-to-diameter ratio is 1.21, and the minimum coolant space between the targets is 0.52 cm (0.20 in.). The target outer coolant flow channel area is 3.07 cm^2 (0.48 in^2). The target inner diameter is 2.20 cm (0.87 in.) with a 0.953 cm (0.375 in.) Al centering rod. The target inner coolant flow channel area is 3.09 cm^2 (0.48 in^2).

Table 4a.5-1 shows the row positions and total core size as a function of the number of complete rows. Figure 4a.2-8 shows the baseline/limiting reactor configuration with 60 targets and reflector matrix. The innermost hexagonal shaped annular row of targets contains six target positions, the second row 12 target positions, etc., or 6*n* target positions in Row *n*. The center position contains the safety rod, which is Al followed. The corner locations, of Row 5 in the Be matrix, contain the four control rods which are Be followed, the neutron source location, and an irradiation location.

The required core size calculated and presented is dependent on the target configuration and target parameters. The design has sufficient positive reactivity to overcome the negative Doppler and moderator density effects in the core at full power, the saturated xenon (Xe) and other fission product poison effects, and burnup of the U-235 during full-power, steady-state operations. Figure 4a.5-2 shows a detailed view of the core.

4a.5.2.2 Analytical Tools and Methods

The Monte Carlo computer code MCNP (Monte Carlo N-Particle) Version 6.2 (MCNP, 2017) was used to perform the neutronic analyses for the core configurations. The combinatorial geometry capability and continuous energy cross-section library of MCNP allows for a significant confidence level to be attained in the accuracy of the k effective multiplication constant (k_{eff}) and flux tally results. All the scoping and preliminary analyses were performed using MCNP.

A discrete, three-dimensional (3-D) model of the core with all the targets, reflector matrix, and control and safety rods uniquely identified was used to perform the MCNP analyses. The discretized model allows for individual targets to be uniquely identified and placed in the core at specified locations. The discretized model allows for analysis of reactivity and peaking effects associated with core configuration permutations. The Evaluated Nuclear Data File version B-VII (ENDF/B-VII) neutron cross-sections (Conlin et al., 2013), denoted by “*.7Xc” in the MCNP cross-section library, were used exclusively in the analysis.

Figure 4a.5-3 shows the plan and elevation view MCNP model for the optimized baseline all-target reactor core. The targets, reflector matrix, Be-followed control rods, and the Al-followed safety rod are identified. Not all the reactor components are included in the baseline MCNP model. In particular, the core shroud and target end fittings are left out of the model. Because these components are fabricated from Al and are located away from the core, their neutron importance, and subsequent reactivity effects, are expected to be small and have a negligible effect on the neutronic analysis results.

The Be reflector matrix is fabricated as six solid pieces to form a hexagon shape, as described in Subsection 4a.2.3. However, for the MCNP model, the Be reflector geometry used individual hexagonal shapes with the same pitch as for the target grid. An outer hexagonal boundary

confined the geometrical shape to a hexagon with water on the outside of the reflector region. This geometry allowed for reflector heating calculations as described in Subsection 4a.5.3.7.2.

The following core, target, and target parameters were analyzed.

Core Configurations Analyzed – Initial Parametric Optimization to Determine Baseline Design (not presented in the PSAR)

- Target number.
- Target dimensions – pitch, diameter, inner rod, fuel length.
- U mass per target.
- Reflector – material type, shape, dimensions.

Core Configurations Analyzed – Optimized Baseline Configuration

- 60 targets – triangular pitch.
- Target dimensions – Table 4a.2-2.
- U mass per target [[ ]]$^{PROP/ECI/SRI}$ baseline.
- U isotopic composition – Table 4a.2-3.
- Reflector – Be metal – [[ ]]$^{PROP/ECI}$.

Conditions Analyzed

- Excess reactivity at 20°C (68°F), β_{eff} , neutron generation time.
- Control and safety rod worth.
- Fuel temperature reactivity effects (Doppler broadening).
- Moderator temperature reactivity effects (spectral and density).
- Reflector temperature reactivity effects (spectral).
- Peaking factors (target-to-target-average and axial).
- Burnup and fission product poisoning reactivity effects.
- Fuel misloading reactivity and peaking effects.
- Target misloading reactivity and peaking effects.
- Heating coefficients.
- Neutron activation.

Unless otherwise specified, the neutronic results represent the reactor core at the beginning of cycle, with the complete core loaded with unirradiated fresh targets. Results for representative fuel life cycles will be presented in the Operating License Application.

4a.5.3 REACTOR CORE PHYSICS PARAMETERS

This subsection presents the MCNP modeling results for the optimized baseline core configuration. The results for all the permutation conditions are presented along with discussion of the importance of the results and the implications on the operating parameters.

4a.5.3.1 Excess Reactivity, Delayed Neutron Fraction, and Neutron Lifetime

Both the β_{eff} and neutron generation time (Λ) for the reactor core are calculated in MCNP using a KOPTS card in the input deck. To have a small statistical uncertainty on these values, the code must be run with more starting neutrons per cycle and more cycles. For the baseline core 1000 million starting neutrons were used in the analysis. The results are as follows:

$$\beta_{eff} = 0.0075 \pm 0.00003 \quad \text{(Equation 4a.5-1)}$$

$$\Lambda = 75.2 \pm 0.05 \text{ microseconds} \quad \text{(Equation 4a.5-2)}$$

These two values are used throughout this chapter and Chapter 13a, when describing reactivity in dollars, and when the neutron generation time is required.

MCNP eigenvalue (k_{eff}) calculations were performed for the baseline reactor core with the modeled materials at 20°C (68°F) and full moderator density for several different permutations. Table 4a.5-2 shows the results for the nominal 60 target configuration with [[ ]]$^{PROP/ECI/SRI}$ U-235) per target fuel loading. Also, calculations with fuel loading of 0.8 and 1.20 times the nominal value were performed, as well as a 15 percent enrichment case. Calculations were performed for the nominal case with the six corner targets removed and replaced with water moderator or a solid Al cylinder. Other cases presented include Al-followed control rods, the irradiation and source locations filled with Be or water, removal of one target in the inner row or outer flat and replaced with water moderator or a solid Al cylinder. The results represent the reactivity excess for the reactor at the initial critical condition at 20°C (68°F) (clean-cold core condition). Fuel temperature, moderator temperature and density, and fission product poisoning and burnup have effects on reactivity, as confirmed in later sections. Excess reactivity is required to reach full-power operating conditions and to overcome the Xe, other fission product poisoning, and fuel burnup effects. These effects are described in later sections along with an analysis of the required excess reactivity to reach full-power operating conditions.

Comparing the nominal condition ([[ ]]$^{PROP/ECI/SRI}$ U per target) to the 1.20 times the nominal fuel loading ([[ ]]$^{PROP/ECI/SRI}$ U per target), the excess reactivity gain is found to be dollar reactivity unit ($) [[ ]]$^{PROP/ECI/SRI}$ LEU loading for 60 targets ([[ ]]$^{PROP/ECI/SRI}$ LEU for one target). For 0.8 times the nominal fuel loading ([[ ]]$^{PROP/ECI/SRI}$ U per target), the reactivity loss is found to be [[ ]]$^{PROP/ECI/SRI}$ LEU loading for 60 targets ([[ ]]$^{PROP/ECI/SRI}$ LEU for one target). A misloading of 10 percent additional LEU in one target ([[ ]]$^{PROP/ECI/SRI}$ LEU) results in a reactivity change of about [[ ]]$^{PROP/ECI/SRI}$.

The 15 percent enriched fuel case represents a condition where the fuel has experienced U burnup and is recycled and reformed into targets. In this case, the fuel loading per target must

be increased by 31.7 percent in order to achieve a U-235 content per target of the nominal [[ ]]PROP/ECI/SRI U-235 (19.75 percent of [[ ]]PROP/ECI/SRI LEU). At this increased loading, the reactivity of the core is [[ ]]PROP/ECI less than for the nominal 19.75 percent [[ ]]PROP/ECI/SRI U case. The burnup effects, as discussed in Subsection 4a.5.3.4, are expected to be [[ ]]PROP/ECI/SRI U-235 per MW-day. One target operating at full power (30 kWt) for 14 days has 0.42 MW-days of burnup, equal to [[ ]]PROP/ECI/SRI U-235 consumed. The enrichment decreases from 19.75 percent to 19.42 percent, a change of about 0.33 percent. To get to 15 percent requires about 14 cycles of the fuel through the reactor core.

Replacing the Be follower in the four control rods with Al results in a negative reactivity change of [[ ]]PROP/ECI. A Be follower is the nominal configuration for the control rods, with an Al follower for the safety rod. Al followers for the control rod may be considered if there is a desire to reduce the excess reactivity in the core, depending on Mo-99 production requirements.

Replacing the Al in the source and irradiation locations in Row 5 of the core with Be or water is found to have a positive [[ ]]PROP/ECI reactivity effect for Be, and virtually no reactivity effect for water.

Replacing the six corner targets (Row 4) with solid Al cylinders of the same diameter as a target or with water results in a negative reactivity effect of [[ ]]PROP/ECI and [[ ]]PROP/ECI respectively, per target. This result means that a target in the corner of Row 4 is worth [[ ]]PROP/ECI. A configuration with the six corner targets removed results in a 54-target core. This configuration, or one with fewer than six targets removed, could potentially allow for operations at the full target power, but with a slightly reduced core size; if there was a desire to reduce the excess reactivity in the core, depending on Mo-99 production requirements.

Replacing an inner row target (Row 1) with Al or water or an outer row target (Row 4) flat with Al or water results in a negative reactivity effect. The negative effects range from [[ ]]PROP/ECI. The negative effect is less for water as compared to Al.

A unique design feature of the reactor is that 60 nominal targets cannot be made into a critical configuration without the Be reflector. There is no pitch or other target configuration that allows for a critical configuration of 60 targets. This allows for target handling and transfer to be accomplished without any criticality limitations (see also Chapter 6b and 9a).

4a.5.3.2 Control and Safety Rod Worth

As described in Subsection 4a.2.2, the reactivity of the reactor is controlled using four control rods and a safety rod that contain neutron absorbing materials. The neutron absorbing material for this analysis is enriched B (96 percent boron-10 [B-10]) in the form of B_4C. The physical makeup of the two different types of rods (control and safety) is also described in Subsection 4a.2.2. The control rods used in this analysis are Be followed. The safety rod is Al followed. Although each of the control rods can be operated independently, they are normally operated as a group to form a “bank.”

For this analysis, several different permutations are presented for the control and safety rods to show that enough flexibility exists in the design to maintain the reactor core in a shutdown (subcritical) state under the most reactive clean (fresh fuel with no fission product poisons or burnup) cold (20°C [68°F]) conditions, and to also allow for enough negative reactivity to allow

for one rod (the most reactive rod is the safety rod) to be stuck in the most reactive condition and maintain subcritical conditions for a clean-cold core.

Figure 4a.5-4 shows the MCNP baseline model with the four control rods and one safety rod fully inserted (full-down) into the core. The baseline case is for the four control rods to be located at four of the six corner positions in the first row of reflector elements (Row 5). The nominal model for the control rods uses an Al cladding with an Al inner liner. The dimensions of the control and safety rods are as follows:

- Al cladding outer diameter = 2.92 cm (1.15 in.) (0.08 cm [0.03 in.] wall thickness).
- Al liner outer diameter = 2.76 cm (1.09 in.) (0.08 cm [0.03 in.] wall thickness).
- B_4C outer diameter = 2.60 cm (1.02 in.).
- Rod height = 72.8 cm (28.7 in.) (between upper and lower grid plates).

All rods fully inserted at their most negative reactivity state is the starting position for any core startup sequence after a target change out, including startup of a fresh core. The operating sequence for the safety and control rods is as follows:

a. The neutron source is inserted mechanically into the core. Once the initial conditions are satisfied for the reactor protection system, the electromagnet for each rod is energized establishing the mechanical coupling of the rod drive mechanism to the rod.
b. The safety rod is fully withdrawn from the core at a predefined rate.
c. The four control rods are removed as a bank at a predefined rate and the reactor is brought to the critical condition.
d. The neutron source is removed from the core.
e. The control rod bank is further removed, allowing the reactor to be brought to a full-power condition in step intervals.
f. With the control rod bank position at full power, excess reactivity in the bank is required to overcome Xe and other fission product poisoning and fuel burnup over the next day or several days of operation, until the next target changeout.

Table 4a.5-3 shows the results of the MCNP calculations compared to the clean-cold conditions to determine the reactivity worth of the safety rod and the four control rods. The statistical uncertainty in the results is ±$0.02. The table shows the results for 96 percent enriched B in the form of B_4C with a density of 1.80 g/cm^3. The differential worth is compared to the nominal, no rods inserted, reactivity state, [[ ]]$^{PROP/ECI}$. The reactivity worth in parentheses represents the reactivity value compared to a k_{eff} value of one.

The worth of the safety rod is about [[ ]]$^{PROP/ECI}$. The worth of the four control rods is about [[ ]]$^{PROP/ECI}$. With all the rods (control and safety) in the full-down position, the reactor is shut down by about [[ ]]$^{PROP/ECI}$. The differential worth of the four control rods is about [[ ]]$^{PROP/ECI}$ with the control rod bank halfway inserted into the core.

The negative worth of the four control rods must be enough to maintain the reactor subcritical for the clean-cold core configuration (initial condition of the core with fresh targets). This ensures that the “stuck rod criteria” (most reactive rod remains in the full-up position) is satisfied. Depending on the final design of the poison section and excess reactivity

requirements for the core, four control rods located at the corner locations allows for accommodation of the 60-target configuration with [[ ]]$^{PROP/ECI/SRI}$ U per target and allows for the “stuck rod criteria” to be met. Other calculations examined different lengths of the poison section of a control and safety rod. It was found that the poison section is only required to be the length of the fuel in the full-down position to have the full reactivity effectiveness of the poison.

4a.5.3.3 Thermal Reactivity Feedback

Thermally induced reactivity feedback effects were analyzed using MCNP for the baseline 60 target reactor core with [[ ]]$^{PROP/ECI/SRI}$ U per target. The analysis includes the following:

- Target fuel temperature changes that increase Doppler broadening effects on reactivity.
- Core moderator and reflector temperature changes that change spectral neutron scattering effects on reactivity.
- Core moderator changes in density that change the moderation effects on reactivity.

The effects were analyzed by changing the parameters uniformly in the core. No importance weighting functions were used in the MCNP model.

4a.5.3.3.1 Thermal Reactivity Feedback

The target cladding is in intimate contact with the fuel foil. As presented in Subsection 4a.6.4, the fuel temperature is a few to tens of degrees higher than the cladding temperature depending on the thermal resistance between the U foil and Al cladding. The cladding and fuel temperature are on the order of 150°C (302°F). The reactivity effects due to fuel temperature changes are dominated by the Doppler broadening of the U-238 absorption cross-section. The target fuel temperature reactivity effects were calculated using MCNP by comparing the 293.6 Kelvin (K) (20°C, 68°F) k_{eff} results to the case where the fuel temperature was at 600 K (327°C, 621°F), 900 K (627°C, 1167°F), and 1200 K (927°C, 1701°F). The change in reactivity was fit to a traditional “square root of the absolute temperature” formulation (Lamarsh, 1972; Duderstadt and Hamilton, 1976). Table 4a.5-4 shows the results of the MCNP calculations for the baseline target core with a nominal [[ ]]$^{PROP/ECI/SRI}$ U per target and the 15 percent enriched ([[ ]]$^{PROP/ECI/SRI}$ U per target) case. The statistical uncertainty in the results is ±$0.02.

The results for both fuel loadings are similar and are found to be consistent with the square root formulation. The square root formulation gives the following results for fuel temperature feedback.

$$\Delta\rho_{\text{fuel}}\big(T(K)\big) = [[\quad]]^{PROP/ECI}\ \left(T(K)^{\frac{1}{2}} - 300^{\frac{1}{2}}\right) \qquad \text{(Equation 4a.5-3)}$$

At 150°C (302°F), the fuel temperature reactivity effect is approximately [[ ]]$^{PROP/ECI}$. Heating to 600 K (327°C, 620°F) results in a reactivity effect of [[ ]]$^{PROP/ECI}$.

4a.5.3.3.2 Moderator and Reflector Spectral Effects

The reactivity spectral effects are due to upscattering of the neutrons as the temperature of the moderator or reflector increases. This is modeled in MCNP by changing the scattering kernel S(α,β) values that are included with the MCNP cross-section set. Analysis was performed to

determine the spectral effects in both the water moderator and Be reflector matrix and the combination with and without voiding effects. The water moderator is heated by direct gamma ray and neutron heating, and from heat transfer from fission in the fuel through the cladding. The reflector elements are heated from direct gamma ray and neutron heating. Heating in both the moderator and reflector from direct gamma rays and neutrons are analyzed and discussed in greater detail in Subsection 4a.5.3.7. Table 4a.5-5 shows the results of the analysis. The statistical uncertainty in the results is ±$0.02.

The spectral effect due to water moderator heating is negative. At 350 K (77°C, 171°F) the reactivity effect is [[ ]]$^{PROP/ECI}$ compared to the 293.6 K (20°C, 68°F) case. Adding the 350 K spectral effect to a moderator density change of 1 percent results in a reactivity change of [[ ]]$^{PROP/ECI}$. Adding the 350 K spectral effect to a moderator density change of 5 percent results in a reactivity change of [[ ]]$^{PROP/ECI}$. The spectral effect in the moderator at 400 K (127°C, 260°F) results in an additional negative reactivity effect of [[ ]]$^{PROP/ECI}$. The Be reflector spectral reactivity effect is positive. With the Be reflector temperature at 400 K (127°C, 260°F), the combined 350 K water temperature and a moderator density change of 1 percent results in a reactivity change of [[ ]]$^{PROP/ECI}$ and, when combined with a moderator density change of 5 percent, [[ ]]$^{PROP/ECI}$. The relative heating of the reflector versus the core regions is shown to be small at 1.8 MWt. Subsection 4a.6.5 shows that, at 1.8 MWt, the peak and average Be matrix temperature is significantly less than 400 K (127°C, 260°F).

Combining the fuel temperature, moderator temperature, moderator density, and reflector temperature, the overall power coefficient for full power operation is negative by [[ ]]$^{PROP/ECI}$ depending on the final equilibrium temperatures of the materials and effective voiding in the moderator.

4a.5.3.3.3 Moderator Density Effects

The water moderator density in the reactor core decreases due to the heating of the water, but also due to bubble formation on the cladding from subcooled nucleate boiling. As discussed in greater detail in Section 4a.6, as the cladding is heated by the fuel, the heat is effectively transferred to the water coolant by subcooled nucleate boiling. Small bubbles form on the cladding and break off into the bulk water channel where they collapse because the water temperature is below the saturation temperature. As the bulk water temperature approaches the saturation temperature, the effective voiding of the coolant increases significantly.

Heating the water moderator from 20°C to 50°C (68°F to 122°F) changes the bulk water density by about 1 percent. However, effective water moderator voiding effects due to subcooled nucleate boiling can be a few to tens of percent depending on the heat flux, the coolant mass flux, and the degree of subcooling.

Table 4a.5-6 shows the MCNP results for the baseline reactor configuration as the bulk water moderator density is changed in the core fuel region. The water temperature S(α,β) is maintained at 20°C (68°F) for the analysis. As expected, the moderator density effects are large and negative. At a density of 0.95, the reactivity change is greater than negative $1. The

reactivity effect on density is relatively linear from a density of 1.0 to 0.8. Valid to about 0.8 density (20 percent density reduction), the reactivity effect due to the water density is approximately:

$$\Delta\rho_{\text{moderator}} = [[\quad]]^{PROP/ECI}\ \Delta density(\%) \qquad \text{(Equation 4a.5-4)}$$

For larger density changes, the density effect increases by about a factor of two.

Large density changes for the water in the core are not expected during normal operations for the reactor. At 1.8 MWt, the water moderator density change is expected to be between 1 percent and 5 percent in the core region. Moderator density changes greater than this are only expected for significantly larger heat flux values than normal, or if the water temperature in the core region approaches 90°C (194°F).

4a.5.3.4 Burnup and Fission Product Poisoning Reactivity Effects

Target fuel burnup and fission product poisoning of the core were analyzed using the MCNP burnup feature. The baseline 60 target reactor core was analyzed with [[ ]]PROP/ECI/SRI U per target. The reactor power was 1.8 MWt equivalent to 30 kWt per target average. The burnup was run for 21 days and then decayed for 2 days.

Figure 4a.5-5 shows the burnup results for the [[ ]]PROP/ECI/SRI U per target core. From these results the xenon-135 (Xe-135) and other fission product poisoning reactivity effects, fuel burnup reactivity effects, and shutdown Xe-135 reactivity effects were determined. The total excess reactivity required to operate at full power for a 21-day fuel cycle is estimated along with the expected fuel mass per target core loading. The solid line in the figure represents the MCNP k_{eff} results as a function of burnup, starting with a clean-cold condition. The dashed line is a linear representation of the reactivity effects as the U-235 is consumed.

The reactivity estimates for the fission product poisoning and fuel burnup are shown in Table 4a.5-7. The uncertainty in the results is ±$0.02. Because the core maintains a relatively large thermal neutron energy spectrum, the Xe-135 reactivity poisoning effects are significant. The equilibrium Xe-135/samarium-149 (Sm-149) reactivity effect is [[ ]]PROP/ECI. The reactivity effects due to fuel burnup (U-235 consumption) and other fission product poisoning are [[ ]]PROP/ECI per day. Reactivity Xe-135 effects after shutdown due to iodine-135 (I-135) feed-in are [[ ]]PROP/ECI at 1 hr. after reactor shutdown, [[ ]]PROP/ECI after 2 hr. of reactor shutdown, and [[ ]]PROP/ECI after 8 hr. of reactor shutdown. At 8 hr., the Xe reactivity effect is at its maximum negative value. Due to the 9.17 hr. half-life of Xe-135, and 6.59 hr. half-life of the I-135 parent isotope, a maximum negative value is reached and then diminishes over time as the isotopes decay as shown in the figure.

Assuming a 21-day continuous cycle for the target fuel at 1.8 MWt and a 2-hr. shutdown time, the excess reactivity requirements for the core can be estimated. Approximately [[ ]]PROP/ECI of reactivity is required for fission product poisoning and fuel burnup. From Subsection 4a.5.3.3, approximately [[ ]]PROP/ECI of reactivity is required for the core to go from clean-cold critical to full power. The total excess reactivity requirements for the core are [[ ]]PROP/ECI. Comparing this result to the results presented in Table 4a.5-2, a core loading of about [[ ]]PROP/ECI/SRI per target ([[ ]]PROP/ECI/SRI U total for core) is sufficient to operate at

1.8 MWt on a 21-day fuel cycle, with the same number of targets removed daily and processed. This allows for three targets to be processed every day or 20 targets per week.

For a 21-day burnup cycle, the burnup on the core at 1.8 MWt is [[ ]]PROP/ECI/SRI U-235, equivalent to [[ ]]PROP/ECI/SRI of U-235 per MW-day. The negative reactivity effect from the U-235 consumption is [[ ]]PROP/ECI/SRI U-235. A target operating at 30 kWt for 21 days experiences 0.63 MW-days, equivalent to [[ ]]PROP/ECI/SRI of negative reactivity. A target operating at 30 kWt for 14 days experiences 0.42 MW-days, equivalent to [[ ]]PROP/ECI/SRI of negative reactivity.

If the Mo-99 product demand is less than 100 percent of the U.S. demand, different operating options are considered to determine the economic feasibility of the production operation. One option is to continue to operate at full power but process the complete core every 21 days (20 targets per week). Power level and operating schedule can be varied to achieve the desired Mo-99 production level within acceptable limits of reactor power (average target power ≤ 30 kW) and target burn-up (≤ 0.75 MW-days).

4a.5.3.5 Power Distribution Within the Core and Targets

The core radial (target-to-target-average) and axial power distribution is calculated using MCNP by tallying the fissions in the cell geometry. Calculations were performed for the baseline 60 target core with [[ ]]PROP/ECI/SRI U per target with the control and safety rods in the full-up (most positive reactivity) position, the control rods halfway inserted into the core, and the control rods in the full-down (most negative reactivity) position. Calculations were also performed with the rods full-up and, for a fresh target at the inner row location, for 0, 1, 2, and 3 hr. following a 7-day burnup.

The target-to-target-average power peaking factor and target axial power peaking factor results are shown in Table 4a.5-8. Due to the effectiveness of the Be reflector in reflecting neutrons back into the core region, the core radial, target-to-target-average peaking factor with all rods in the full-up position is small. The peak target occurs in the first row of six targets and is 5.4 percent greater than the average target power with the control rods fully withdrawn. The axial peaking factor in the first row of six targets is about 1.23, which is typical for small thermal reactors. The peak target would be operated at 31.6 kWt instead of the average 30 kWt with the control and safety rods full-up. The target-to-target average peaking factor does increase with the control rods inserted into the core. For the control rods halfway inserted into the core, the peak target is 12 percent greater than the average target power. The peak target power would be 33.6 kWt. For the control rods fully inserted into the core, the peak target is 18 percent greater than the average target power. The peak target power would be 35.4 kWt. These values are well within the operating limits of the target established in Subsection 4a.5.4. For a fresh target in the first row and a 7-day burnup, the target peaking only increases slightly (2.5 percent to 1.080) compared to the fresh target condition.

4a.5.3.6 Target Irregularities

Three target irregularities were analyzed using MCNP with the 60-target baseline core with [[ ]]PROP/ECI/SRI U per target:

- A missing target in either the inner row of targets or outer row of targets, replaced with water or a solid Al cylinder of the same diameter as a target.

- Six missing targets in the outer corners replaced with water or solid Al cylinders.
- A target that has 1.5 times the nominal amount of U per target in either the inner row of targets or outer row of targets.

Both the reactivity effects and peaking factor anomalies were calculated for these conditions.

A missing target in the first row decreases the excess reactivity in the core by [[ ]]$^{PROP/ECI}$ when replaced with Al or water, respectively (see Table 4a.5-2). The axial peaking factor does not change for the nearest neighbor targets. The target-to-target-average peaking factors are 1.083 and 1.164 for the target next to the missing one in the first row for replacement with Al or water, respectively. The nearest neighbor target in the second row does not change in value.

A missing target in the outer row decreases the excess reactivity in the core by [[ ]]$^{PROP/ECI}$ when replaced with Al or water, respectively (see Table 4a.5-2). The axial peaking factor does not change for the nearest neighbor targets. The target-to-target-average peaking factors are 1.034 and 1.114 for the target next to the missing one in the outer row, for replacement with Al or water, respectively. The nearest neighbor target in the next inner row does not change in value.

Six missing targets at the outer corner locations of the core decrease the excess reactivity in the core by [[ ]]$^{PROP/ECI}$ per target when replaced with Al or water, respectively (see Table 4a.5-2). The axial peaking factor does not change for the nearest neighbor targets. The target-to-target-average peaking factors are 1.042 and 1.088 for the target next to the missing one in the outer row, for replacement with Al or water, respectively. The nearest neighbor target in the next inner row does not change in value.

A misloaded target, with 1.5 times the U nominal loading, in the first row increases the excess reactivity in the core by [[ ]]$^{PROP/ECI}$. The axial peaking factor does not change. The target-to-target-average peaking factor is 1.171 for the misloaded target. The target next to the misloaded one in the first row does not change in value. The nearest neighbor target in the second row does not change in value.

A misloaded target in the outer row, with 1.5 times the U nominal loading, increases the excess reactivity in the core by [[ ]]$^{PROP/ECI}$. The axial peaking factor does not change. The target-to-target-average peaking factor is 1.126 for the misloaded target. The target next to the misloaded one in the outer row does not change in value. The nearest neighbor target in the next inner row does not change in value.

These results indicate that for a missing target replaced with water, the target-to-target-average peaking factor could be as high as 1.164, depending on the location. The peak target would be operated at 34.9 kWt instead of the average 30 kWt. This is well within the operating limits of the target established in Subsection 4a.5.4. If a target in the outer row was replaced with a solid Al cylinder, the highest target-to-target average peaking factor would be 1.042, which is lower than the radial peaking factor for the nominal 60-target core (see Subsection 4a.5.3.5). A misloaded target with 1.5 times the U loading could result in a target-to-target average peaking factor of 1.171. The peak target would be operated at 35.1 kWt instead of the average 30 kWt. Again, this is well within the operating limits of the target established in Subsection 4a.5.4.

4a.5.3.7 Direct Neutron and Gamma Ray Heating

MCNP calculations were performed for the baseline 60 target reactor core with [[ ]]PROP/ECI/SRI U per target to determine the neutron and prompt gamma-ray (fission and radiative capture) heating (energy deposition) in the core. A type 6 volume tally is used for the cells of interest in the model. For this analysis, heating in the water moderator and Be reflector was calculated on a fractional basis compared to the total reactor power, for the baseline 60 target, Be reflector matrix configuration. The MCNP tally results are in units of million electron volts (MeV) per g per source neutron. Multiplying the tally by the mass of the cell in grams and v (2.44 neutrons per fission) and dividing by k_{eff} and the energy per fission (195 MeV per fission) results in the fraction of energy deposited in the cell. The fractional heating values are used to determine the temperature and cooling requirements for the reflector matrix under steady-state and accident conditions and the water moderator temperature and voiding under accident conditions.

4a.5.3.7.1 Water Moderator Heating

The water moderator heating in the fuel region of the core was calculated using MCNP for the nominal 60 target baseline configuration with [[ ]]PROP/ECI/SRI U per target. The results are shown in Table 4a.5-9 for the neutron and prompt gamma-ray heating fractions. The calculation was performed for all 60 target channels, because the target-to-target-average peaking factors are small. Approximately 2.1 percent of the total reactor power (37.8 kWt at 1.8 MWt reactor power) is directly deposited into the water moderator region of the targets (40 cm [15.7 in.] height) from neutron and prompt gamma-ray heating. The neutron heating is about twice that of the gamma-ray heating. This result represents the instantaneous direct heating of the moderator and the associated prompt moderator reactivity feedback effects.

4a.5.3.7.2 Be Reflector Heating

The Be reflector heating over the 60 cm (23.6 in.) reflector height was calculated using MCNP for the nominal 60 target baseline configuration with [[ ]]PROP/ECI/SRI U per target and a flat-to-centerline Be reflector of 22.4 cm (8.82 in.). Although the Be reflector is six solid pieces as described in Subsection 4a.2.3, for the MCNP neutronics model, the Be reflector was maintained as hexagonal shapes with the same pitch as for the target grid, as described in Subsection 4a.5.2.2. An outer hexagonal boundary conformed the geometrical shape to a hexagon with water on the outside of the reflector region. This method allowed for reflector heating calculations to be performed in a straightforward fashion. The reflector equivalent geometry is approximately four rows of hexagonal elements.

The calculation was performed for an equivalent row-by-row hexagonal grid geometry and for individual elements in Rows 1 through 4. The total direct heating in the reflector is 1.58 percent of the total reactor power (28.4 kWt at 1.8 MWt reactor power). The average total direct heating per row is 0.51 percent for Row 1, 0.45 percent for Row 2, 0.35 percent for Row 3, and 0.27 percent for Row 4. The gamma-ray heating is about 2.5 times that of the neutron heating.

Table 4a.5-10 shows the results for the neutron and prompt gamma-ray heating fractions per cm^3 for the peak (flat) locations in each row and their relation to the row average and core average. These results are used in Subsection 4a.6.5 to determine the reflector temperatures with the reactor at a steady-state power level of 1.8 MWt. The peak to average values in each row is not significant, on the order of 5 percent to 10 percent larger than the average heating density in each row. The heating density in Row 1 is about 2.1 times the average in the total

reflector, Row 2 is 1.3 times the average, Row 3 is 0.86 times the average, and Row 4 is 0.58 times the average. Although the heating is significantly larger in Row 1 compared to the rest of the reflector, the maximum temperature is not expected in Row 1 because there is a significant amount of water cooling on the inner surface of the reflector.

Table 4a.5-11 shows the results for the neutron and prompt gamma-ray heating axial peaking factors in the Row 5 position of the reflector. The peak-to-average at the axial centerline is calculated to be 1.6. These results are used in Subsection 4a.6.5 to determine the steady-state temperature distribution in the reflector matrix and its associated reactivity effects on the core.

4a.5.3.7.3 Control Rod Heating

The control rod heating was calculated using MCNP for the nominal 60 target baseline configuration with [[ ]]$^{PROP/ECI/SRI}$ U per target. Two cases were analyzed for the nominal control rod geometry:

- Control rod bank halfway into the core (at core centerline) with 96 percent enriched B in B_4C.
- Control rod bank 15 cm (5.9 in.) above the core centerline with 96 percent enriched B in B_4C.

The heating tally at the end of the control rod was divided into two 1-cm (0.39-in.) long pieces, each with five radial segments of equal dimension. The highest heating effects in the poison section of a control rod with the reactor at full power and the control rod bank halfway into the core are at the peak axial neutron flux location. The bottom of the control rod poison section has larger heating values because the bottom face is exposed to a larger neutron flux.

Table 4a.5-12 shows the results for the neutron and prompt gamma-ray heating fractions/cm^3 for the bottom 2 cm (0.79 in.) of control rod poison with the control rod bank halfway into the core for 96 percent enriched B. The results with the control rod bank 15 cm (5.90 in.) above the core centerline are not presented in the table. However, the results at 15 cm (5.90 in.) above the core centerline are about 30 percent lower than with the control rod bank halfway into the core. The neutron heating dominates the effects in the control rod poison section. The neutron heating is 3 to 25 times larger than the gamma-ray heating, depending on the tally location. The results show that the outer radius of the poison rod has significantly more heating than the internal section of the rod. The outer 0.26 cm (0.10 in.) of the poison is about seven times larger in heating density than the inner portion of the rod. This is due to the neutron self-shielding effects owing to the very larger neutron absorption cross-section for the B-10. These results are used in Subsection 4a.6.6 to determine the control rod temperatures with the reactor at a steady-state power level of 1.8 MWt.

4a.5.3.8 Be Reflector Worth

MCNP calculations were performed for the baseline 60 target reactor core with [[ ]]$^{PROP/ECI/SRI}$ U per target to determine the worth of the Be reflector for different reflector heights and thicknesses. The baseline model presented in Subsection 4a.5.2.2 has a solid Be metal reflector that is [[ ]]$^{PROP/ECI}$ from the center of the core to the radial flat of the reflector ([[ ]]$^{PROP/ECI}$ flat-to-flat). The reflector is [[ ]]$^{PROP/ECI}$ in height and is centered at the axial centerline of the targets. Al is on both ends of the reflector to position it within the core grid structure. Although this configuration is the nominal baseline design, some flexibility is required if it is determined that additional reactivity is needed to meet

the burnup reactivity requirements. The baseline design does meet the excess reactivity requirement and shutdown margin requirement for operating at 1.8 MWt on a 21-day target cycle as described in Subsection 4a.5.3.4.

The MCNP results for different reflector heights show that, for a 40 cm (15.7 in.) target fuel length, a [[ ]]PROP/ECI reflector height is the optimal design. The reflector savings in adding additional Be reflector material to the ends of the reflector only adds a few cents of reactivity.

The MCNP results for different ΔR are presented in Table 4a.5-13. The excess reactivity for the baseline configuration is [[ ]]PROP/ECI. Adding additional Be reflector material to the outside of the reflector radius can add significant reactivity to the system. An additional 5 cm (1.97 in.) of Be reflector adds [[ ]]PROP/ECI of reactivity to the core, 10 cm (3.93 in.) results in an addition of [[ ]]PROP/ECI, and 15 cm (5.90 in.) results in an addition of [[ ]]PROP/ECI. The reflector savings are diminished past this thickness.

The results of Subsection 4a.5.3.4 indicate that enough excess reactivity exists in the baseline core configuration with [[ ]]PROP/ECI/SRI U per target, a [[ ]]PROP/ECI Be reflector height, and a [[ ]]PROP/ECI flat-to-flat Be reflector dimension. Some contingencies are designed into the reflector Al end structure that allow for the accommodation of additional Be metal plates, if additional reactivity is needed for the core.

4a.5.3.9 Be Reflector Neutron Flux and Helium Production

The neutron irradiation damage in Be metal has been studied and documented related to its use in high-flux reactors and space reactors as a reflector material (Burkholz, 1966a; Burkholz, 1966b; Abdullah et al., 1999; Snead and Zinkle, 2005; Bejarano and Cocco, 2011; Longhurst and Rohe, 2007). Primarily due to the alpha particle (He) emission from the (n,2n) and decay reactions, substantial loss of material strength, volumetric expansion, and degradation of the thermal conductivity can occur for fast neutron fluences (E > 1 MeV) above 1E21 neutrons (n)/cm^2. High temperature He embrittlement is a concern for Be components exposed to fast neutron fluences greater than 1E21 n/cm^2 at temperatures above 500°C (932°F) (Snead and Zinkle, 2005). Neutron irradiation studies have observed that the strength of irradiated Be decreases rapidly at temperatures above 600°C (1112°F) in specimens irradiated to fast neutron fluences greater than 1E21 n/cm^2 (Snead and Zinkle, 2005). The effects at lower irradiation temperatures are diminished. Swelling of 0.5 percent is observed for irradiation temperatures up to 400°C (752°F) and a He production of 7000 He atom parts per million (appm) (Longhurst and Rohe, 2007). Swelling of about 0.5 percent is typical at replacement in the Advanced Test Reactor (ATR), although the specific time of replacement is determined by visual inspection for cracks and dimensional changes (Longhurst and Rohe, 2007). For the ATR, the He production of 7000 He appm is equivalent to a fast neutron fluence of 2E22 to 5E22 n/cm^2. Be reflectors in high-flux research reactors are typically replaced after being exposed to a fast neutron fluence of 1E22 to 7.9E22 n/cm^2 (Bejarano and Cocco, 2011).

MCNP calculations were performed for the baseline 60 target reactor core with [[ ]]PROP/ECI/SRI U per target to determine the greater than 1-MeV neutron flux in the Be reflector. The fast neutron flux (> 1 MeV) was calculated using MCNP for the individual reflector hexagonal element geometry in the MCNP model of the core. A type 4 volume tally with no multiplier card was used with an energy binning card for the cells of interest. The tally results were converted to MW-s using the same methodology presented in Subsection 4a.5.3.7. The results are presented in Table 4a.5-14 for the average fast neutron flux in each row and Table

4a.5-15 for the peak fast neutron flux in each row. The axial fast neutron flux was also calculated using the MCNP model.

The Row 5 (closest to core) reflector element location has a fast neutron flux (> 1 MeV) of [[ ]]$^{PROP/ECI}$ n/cm^2 per MW-s for the peak and average locations, respectively. The average fast neutron flux for all the reflector elements is [[ ]]$^{PROP/ECI}$ n/cm^2 per MW-s. For Row 6, the peak fast neutron flux decreases as compared to Row 5 by a factor of 1.9. For Row 7, a factor of 3.4, and Row 8, 6.6. The axial neutron flux peaking factor is found to be 1.70.

At a reactor power of 1.8 MWt, the fast neutron flux (> 1 MeV) at the peak element and axial location in the reflector is [[ ]]$^{PROP/ECI}$ n/cm^2-s. For the reactor operating at full power for one year, the fast neutron fluence is [[ ]]$^{PROP/ECI}$ n/cm^2 at the peak location. This value is [[ ]]$^{PROP/ECI}$ times less than the [[ ]]$^{PROP/ECI}$ n/cm^2 fast fluence and [[ ]]$^{PROP/ECI}$ times less than the [[ ]]$^{PROP/ECI}$ n/cm^2 fast fluence reported by Bejarano and Cocco (Bejarano and Cocco, 2011). Using these comparisons, the all-target reactor Be reflector is expected to last at least 15 years with the reactor operating at full power.

He is produced in the Be reflector matrix from the beryllium-9 (Be-9)(n,2n) reaction, which creates beryllium-8 (Be-8) that decays instantaneously into two alpha particles, and from the Be-9(n,α) reaction, which creates helium-6 that decays instantaneously to lithium-6 (Li-6). The Li-6(n,α) reaction has a large cross-section that produces a He and H-3 atom. It can therefore be assumed that both the Be-9(n,2n) and Be-9(n,α) reactions produce two He atoms.

MCNP calculations were performed for the baseline 60 target reactor core with [[ ]]$^{PROP/ECI/SRI}$ U per target to determine the He production in the Be reflector. The He production was calculated using MCNP for the individual reflector hexagonal element geometry in the MCNP model of the core. A type 4 volume tally with a multiplier card for the (n,2n) or (n, α) reaction was used for the cells of interest. The tally results were converted to MW-s using the same methodology presented in Subsection 4a.5.3.7. The results are presented in Table 4a.5-16 for the average He production in each row and Table 4a.5-17 for the peak He production in each row.

The total He production rate in the Be reflector is 6.7E15 He atoms/MW-s; equivalent to [[ ]]$^{PROP/ECI}$ He atoms/cm^3-MW-s, or [[ ]]$^{PROP/ECI}$ He atoms/Be atom-MW-s. The Row 5 (closest to core) reflector element location has a total He production rate of [[ ]]$^{PROP/ECI}$ He atoms/cm^3-MW-s, or [[ ]]$^{PROP/ECI}$ He atoms/Be atom-MW-s, for the row average, and [[ ]]$^{PROP/ECI}$ He atoms/cm^3-MW-s, or [[ ]]$^{PROP/ECI}$ He atoms/Be atom-MW-s, for the peak. The peak axial production rate is assumed to be the same as for the fast neutron flux, 1.70.

At a reactor power of 1.8 MWt, the He production rate at the peak element and axial location in the reflector is [[ ]]$^{PROP/ECI}$ He atoms/cm^3-s, or [[ ]]$^{PROP/ECI}$ He atoms/Be atom-s. For the reactor operating at full power for one year, the He production is [[ ]]$^{PROP/ECI}$ He atoms/cm^3, or [[ ]]$^{PROP/ECI}$ He atoms/Be atom, at the peak location. The 0.5 percent swelling value (ATR reflector lifetime value) reported by Bejarano and Cocco is 7000 appm (He atom/Be atom), equivalent to 7.0E-3 He atoms/Be atom (Bejarano and Cocco, 2011). The all-target reactor reflector value is [[ ]]$^{PROP/ECI}$ times less than this value. Using this comparison, the all-target reactor Be reflector is expected to last at least [[ ]]$^{PROP/ECI}$ years with the reactor operating at full power, before any significant cracking is expected to form in the matrix.

4a.5.3.10 Control Rod Helium Production

The poison effect of B_4C is from the absorption of neutrons is by the reaction:

$$^{10}B + n \rightarrow {}^{11}B \rightarrow {}^{7}Li + {}^{4}He \qquad \text{(Equation 4a.5-5)}$$

which results in the depletion of one atom of B-10 and the production of an alpha particle (He atom). Thus, continued operation of the reactor results in buildup of He in the B_4C matrix. It is desired to have the control rods almost fully withdrawn from the core when at full-power operating conditions. At this position, neutron absorption is minimized in the poison section of the control rods.

Control rod He production was calculated using the same MCNP model and the same cases as were used for the control rod heating calculations. He is produced by the B-10(n, α) reaction in the B_4C poison section of the control rod. The purpose in calculating the He production is to determine the pressure that the sealed poison section of the control rod could experience over its lifetime, if the He escaped the B_4C pellets. The fabricated poison section is backfilled with approximately 0.2 MPa (29.4 psia) of He and is sealed during the manufacturing process. A void section at least 15 cm (5.90 in.) in length exists above the poison section to collect additional He that is produced in the B_4C and escapes the pellets. The void (He filled) volume is at least 90 cm^3 (5.5 in^3).

A type 4 volume tally with a multiplier card for the (n, α) reaction was used for the cells of interest. The tally results were converted to MW-s using the same methodology presented in Subsection 4a.5.3.7. The results are presented in Table 4a.5-18 for the total He production rate for enriched B in B_4C for a single control rod halfway and 15 cm (5.90 in.) removed from the core for the baseline 60 target reactor core with [[ ]]$^{PROP/ECI/SRI}$ U per target.

The He production rate with the control rod 15 cm (5.90 in.) from the core centerline is about [[ ]]$^{PROP/ECI}$ than with the rod halfway into the core. At a reactor power of 1.8 MWt, the total He production rate for enriched B with the control rod halfway into the core is [[ ]]$^{PROP/ECI}$ moles He/s. For the reactor operating at full power for one year, the He production is [[ ]]$^{PROP/ECI}$ moles.

The He production for a year's operation for the end 0 – 1 cm of control rod length is calculated to be [[ ]]$^{PROP/ECI}$ moles/cm^3 or [[ ]]$^{PROP/ECI}$ moles total. The outer portion of the pellet is found to have about [[ ]]$^{PROP/ECI}$ times the He production density compared to the average, equal to [[ ]]$^{PROP/ECI}$ moles/cm^3. The He production in the 1 – 2 cm length is calculated to be [[ ]]$^{PROP/ECI}$ moles/cm^3 or [[ ]]$^{PROP/ECI}$ moles total. The outer portion of the pellet is found to have about [[ ]]$^{PROP/ECI}$ times the He production density compared to the average, equal to [[ ]]$^{PROP/ECI}$ moles/cm^3.

Assuming [[ ]]$^{PROP/ECI}$ of void space in the control rod and a release fraction of 10 percent (Pitner and Russcher, 1970; Maruyama et al., 1997), the pressure change in the poison section of the control rod is [[ ]]$^{PROP/ECI}$. If the cladding is 1.38 cm (0.54 in.) in diameter and 0.08 cm (0.031 in.) in wall thickness, the tangential stress in the cladding is [[ ]]$^{PROP/ECI}$. The yield strength (0.2 percent offset yield strength) for Al-6061-T6 is 252 MPa (37 thousand pounds per square inch) (Lyman,

1960). It would take over [[ ]]PROP/ECI years of operation at full power with the control rod halfway inserted into the core to reach the 0.2 percent offset yield strength.

Additional analysis presented in Subsection 4a.7.3 examines swelling, He gas release, cracking, and fracturing that can occur in B_4C as a function of burnup.

4a.5.3.11 Activation Products

MCNP calculations were performed for the baseline 60 target reactor core with [[ ]]PROP/ECI/SRI U per target to determine the neutron activation products, Ar-41, N-16, and H-3 in the water moderator. A type 4 volume tally with a multiplier card for the desired reaction was used for the cells of interest. The tally results were converted to MW-s using the same methodology presented in Subsection 4a.5.3.7.

4a.5.3.11.1 Argon-41 Production in Water Moderator

Ar-41 has a 1.83-hour half-life and is produced by the (n,γ) reaction from the stable isotope argon-40 (Ar-40). Ar-40 is 99.59 percent abundant. In air, argon (Ar) is found at 0.934 mole percent. The solubility of Ar in water at 20°C (68°F) and 1 bar (14.5 psi.) is 62 milligram (mg)/L. For standard temperature and pressure air over a water surface, the Ar concentration in the water is calculated to be 0.52 mg/L using Henry's law of partial pressures.

The result for the Ar-41 production in water moderator in the core, reflector, and surrounding regions is calculated to be [[ ]]PROP/ECI reactions per atom per b-cm per source neutron. Multiplying by the Ar-40 atom density in water results in a value of [[ ]]PROP/ECI reactions per source neutron. Multiplying by the conversion factors results in a value of [[ ]]PROP/ECI Ar-41 atoms produced per MW-s. This production rate is equivalent to a saturated activity of [[ ]]PROP/ECI of Ar-41 in the water per MW.

4a.5.3.11.2 Nitrogen-16 Production in Water Moderator

N-16 has a 7.1-s half-life and is produced by the (n,γ) reaction from the stable isotope nitrogen-15 (N-15), and by the (n,p) reaction from the stable isotope oxygen-16 (O-16). The (n,γ) activation reaction is produced by N that is dissolved in the water, like that of Ar.

MCNP results show that the N-15(n,γ) reaction is about [[ ]]PROP/ECI times less probable than the O-16(n,p) reaction and is therefore dismissed in this analysis. The result for the N-16 production from the O-16(n,p) reaction in the water moderator in the core, reflector, and surrounding regions is calculated to be [[ ]]PROP/ECI reactions per atom per b-cm per source neutron. O-16 is 99.756 percent abundant. Multiplying by the O-16 atom density in water results in a value of [[ ]]PROP/ECI reactions per source neutron. Multiplying by the conversion factors results in a value of [[ ]]PROP/ECI N-16 atoms produced per MW-s. This production rate is equivalent to a saturated activity of [[ ]]PROP/ECI Ci of N-16 in the water per MW.

4a.5.3.11.3 Tritium Production in Water Moderator

H-3 has a 12.33-year half-life and is produced by the (n,γ) reaction from the stable isotope deuterium (H-2). Deuterium is 0.015 percent abundant. Deuterium exists in its natural abundance density with the hydrogen in the water.

The result for the H-3 production in water moderator in the core, reflector, and surrounding regions is calculated to be [[ ]]PROP/ECI reactions per atom per b-cm per source neutron. Multiplying by the deuterium density in water results in a value of [[ ]]PROP/ECI reactions per source neutron. Multiplying by the conversion factors results in a value of [[ ]]PROP/ECI H-3 atoms produced per MW-s. This production rate is equivalent to a saturated activity of [[ ]]PROP/ECI Ci of H-3 per MW.

4a.5.3.12 Inherent Neutron Source

An inherent neutron source is expected in the core due to photonuclear reactions (γ,n) with the Be in the reflector after some burnup on the core is experienced. This reaction is a threshold reaction requiring the gamma-ray energy from fission product decay to be greater than 1.66 MeV. Several fission products can be identified that decay with gamma-ray energies above this threshold value. Other activation produced isotopes, such as Co-60, do not produce gamma rays with sufficient energy for the reaction to occur. The source gamma-rays for the reaction are from fission products with longer half-lives (Keepin, 1965). Whether an inherent source exists or not, a neutron startup source is required for reactor startup because there are conditions when a clean-cold core is required with no fission products in the core. An inherent source adds to the startup source neutron contribution, but has unique effects on safety considerations, because the presence of a neutron source in the core is required to meet the reactor protection system requirements described in Chapter 7a.

4a.5.4 OPERATING LIMITS

Subsections 4a.5.1 and 4a.5.2 described the nuclear design considerations and MCNP calculative results for a 60-target baseline core configuration. Parametric studies were performed to determine the sensitivity of the results to the baseline configuration. Three U target loading configurations were analyzed: a [[ ]]PROP/ECI/SRI U loading, a [[ ]]PROP/ECI/SRI U loading, and a [[ ]]PROP/ECI/SRI U loading, all at 19.75 percent U-235 enrichment. The [[ ]]PROP/ECI/SRI U loading was chosen as the nominal baseline core configuration. A 15 percent U-235 enrichment with [[ ]]PROP/ECI/SRI U loading was also examined. Fuel, moderator, and reflector temperature neutronic analyses were performed to determine their reactivity effects on the core. Control and safety rod reactivity worths were calculated for 96 percent B-10 enriched B_4C and different position configurations. Burnup analyses were performed to determine the required excess reactivity for a core operating at 1.8 MWt in a 21-day continuous cycle, where an equal number of targets are removed from the core daily (approximately 3 per day) and replaced with fresh targets.

From these analyses, the excess reactivity requirements, target loading, and control rod and safety rod worth can be calculated that show that the reactor core can be operated safely with regular interval replacement of irradiated targets with fresh ones. Assuming that identical targets are manufactured to within specified tolerances, the core operating behavior is safe, predicable, and reliable.

From the neutronic thermal analysis, approximately [[ ]]PROP/ECI of excess reactivity is required to bring a clean-cold target core configuration from critical to a steady-state operating power level of 1.8 MWt (average target power of 30 kWt), depending on the actual moderator density (i.e., void fraction) that is experienced. The nominal condition assumes that at full power, a void fraction of 1 percent exists in the moderator coolant, which requires about [[ ]]PROP/ECI of excess reactivity to operate at full power. For a 5 percent void fraction, [[ ]]PROP/ECI of excess reactivity is required to operate at full power.

From the burnup analysis, approximately [[ ]]$^{PROP/ECI}$ of reactivity is required to operate a full power in a 21-day continuous cycle, with a 2-hr. shutdown time for target replacement.

Adding these two values results in an excess reactivity requirement of [[ ]]$^{PROP/ECI}$ for the core. For this reactivity requirement, a target loading of [[ ]]$^{PROP/ECI/SRI}$ of U per target is expected to be sufficient for full production operations.

From the control and safety rod neutronic analysis, using 96 percent B-10 enriched B_4C, the reactivity state of the nominal core configuration with [[ ]]$^{PROP/ECI/SRI}$ U per target with the four control rods and one safety rod fully inserted into the core (most negative configuration) is [[ ]]$^{PROP/ECI}$. With the four control rods fully inserted and the safety rod fully withdrawn from the core, the reactivity state is at least [[ ]]$^{PROP/ECI}$. This infers that the reactivity worth of the control and safety rods is sufficient to maintain a clean-cold core subcritical, even with the most reactive safety rod in the full-up position.

The operating sequence is as follows. The reactor is made subcritical by inserting all the control and safety rods into their full-down, most negative, reactivity state positions. The desired number of irradiated targets are removed from the core and placed into the irradiated target transfer basket for processing. The same number of fresh targets are added to the core configuration. The core is inspected, the configuration management procedure is satisfied, and the reactor is ready to be brought back to full power.

The operating sequence for the safety and control rods is relatively simple. After the neutron source is inserted into the core using a motor-drive mechanical system and the initial conditions established at the control console, including meeting the defined reactor protection system conditions, the electromagnet for each rod is energized. The safety rod is fully withdrawn from the core at a predefined rate. The core remains subcritical. The four control rods are removed as a bank at a predefined rate and the reactor is brought to the critical condition. The startup source is removed from the core by the motor-drive system. The control rod bank is further removed, allowing the reactor to be brought to a full-power conditions in predefined step intervals. At full power, reactivity continues to be added by further withdrawing the control rod bank to overcome Xe-135 and other fission product poisoning and fuel burnup over the next day or several days of operation. It is expected that there is little, if any, excess reactivity available at full power, other than that required to overcome the fuel burnup effects over the next day or several days. This quantity of reactivity is expected to be less than [[ ]]$^{PROP/ECI}$. Additional excess reactivity is required to accommodate the shutdown Xe override reactivity effects.

Table 4a.5-1
Number of Targets per Row

Row Number	Number of Targets in Row	Number of Targets in Core
0	0 – safety rod	0
1	6	6
2	12	18
3	18	36
4	24	60 total number of targets
5	4 control rods	--

Table 4a.5-2
MCNP k_{eff} Results for the 60 Target Baseline Core – 19.75% Enriched

Reactor Configuration	k_{eff}	Excess Reactivity ($)
Nominal 60 targets – [[ ]]$^{PROP/ECI/SRI}$ U per target	[[	[[
0.80 x nominal fuel – [[ ]]$^{PROP/ECI/SRI}$ U per target		
1.20 x nominal fuel – [[ ]]$^{PROP/ECI/SRI}$ U per target		
15% enriched fuel – [[ ]]$^{PROP/ECI/SRI}$ U per target		
Nominal – with control rod Al followed		
Nominal – with two location Be		
Nominal – with two location water	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$
Nominal with 6 corners removed – Al	[[	[[
Nominal with 6 corners removed – water		
Nominal with 1 inner row removed – Al		
Nominal with 1 inner row removed – water		
Nominal with 1 outer flat removed – Al		
Nominal with 1 outer flat removed – water	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: MCNP = Monte Carlo n-particle | k_{eff} = k effective multiplication constant | $ = dollar reactivity unit | U = uranium | Al = aluminum | Be = beryllium

Table 4a.5-3
Control and Safety Rod Worth for the 60 Target Baseline Core – Natural Boron and 96% Enriched in B-10

Reactor Configuration Enriched Boron – 96% B-10	k_{eff}	Differential Reactivity Worth Compared to Nominal ($)
Nominal – no rods inserted	[[	[[
Safety rod full-down		
Safety rod + four control rods full-down		
Four control rods full-down		
Control rods halfway down		
Control rods halfway down + 5 cm		
Control rods 15 cm down		
Control rods 20 cm down (fuel height)	]]PROP/ECI	]]PROP/ECI

Abbreviations: B-10 = boron-10 | k_{eff} = k effective multiplication constant | $ = dollar reactivity unit | cm = centimeter(s)

Table 4a.5-4
Change in Reactivity Versus Target Fuel Temperature

Reactor Condition		Change in Reactivity Worth ($)
Nominal + 600 K fuel		[[
Nominal + 900 K fuel		
Nominal + 1200 K fuel		
15% enriched – [[fuel	]]$^{PROP/ECI/SRI}$ U per target + 600 K	
15% enriched – [[fuel	]]$^{PROP/ECI/SRI}$ U per target + 900 K	
15% enriched – [[fuel	]]$^{PROP/ECI/SRI}$ U per target + 1200 K	]]$^{PROP/ECI}$

Abbreviations: $ = dollar reactivity unit | K = Kelvin | U = uranium

Table 4a.5-5
Change in Reactivity Versus Water Moderator Temperature and Reflector Temperature – Spectral Effect

Reactor Condition	Change in Reactivity Worth ($)
Nominal + 350 K water core and above core	[[
Nominal + 400 K water core and above core	
Nominal + 350 K + 0.99 density water core and above core	
Nominal + 400 K + 0.99 density water core and above core	
Nominal + 350 K + 0.95 density water core, 0.99 above core	
Nominal + 400 K + 0.95 density water core, 0.99 above core	
Nominal + 400 K Be reflector + 350 K + 0.99 density water core and above core	
Nominal + 400 K Be reflector + 400 K + 0.99 density water core and above core	
Nominal + 400 K Be reflector + 350 K + 0.95 density water core, 0.99 above core	
Nominal + 400 K Be reflector + 400 K + 0.95 density water core, 0.99 above core	]]PROP/ECI

Abbreviations: $ = dollar reactivity unit | K = Kelvin | Be = beryllium

Table 4a.5-6
Change in Reactivity Versus Water Moderator Density at 20°C for the 60 Target [[ ]]$^{PROP/ECI/SRI}$ U per Target Core

Water Density	Change in Reactivity Worth ($)
0.99	[[
0.95	
0.90	
0.85	
0.80	
0.75	
0.70	
0.65	
0.60	
0.55	
0.50	]]$^{PROP/ECI}$

Abbreviations: °C = degrees Celsius | g = gram(s) | U = uranium | $ = dollar reactivity unit

Table 4a.5-7
Reactivity Effects from Burnup – 21-Day Cycle at 1.8 MWt

Reactor Configuration	Change in Reactivity Worth ($)
Xe-135/Sm-149 poisoning – equilibrium	[[
Fuel burnup total core (per day)	
Xe poisoning – shutdown (1 hr.)	
Xe poisoning – shutdown (2 hr.)	
Xe poisoning – shutdown (8 hr.)	
Fuel burnup for 21-day cycle (20 targets/7 days)	
Excess reactivity required – burnup (1 hr.)	
Excess reactivity required – burnup (2 hr.)	
Excess reactivity required – burnup + temp (1 hr.)	
Excess reactivity required – burnup + temp (2 hr.)	]]PROP/ECI

Abbreviations: MWt = megawatt-thermal | $ = dollar reactivity unit | Xe-135 = xenon-135 | Sm-149 = samarium-149 | Xe = xenon | hr. = hour(s)

Table 4a.5-8
Core Power Peaking Factors for the 60 Target Configuration

Reactor Condition	Peaking Factor
Target-to-target-average – all rods full-up	1.054 ± 0.13%
Axial – all rods full-up	1.227 ± 0.5%
Target-to-target-average – control rods halfway down	1.121 ± 0.13%
Axial – control rods halfway down	1.234 ± 0.5%
Target-to-target-average – control rods full-down	1.179 ± 0.13%
Axial – control rods full-down	1.227 ± 0.5%
Target-to-target-average – all rods full-up - 0 hr. after shutdown	1.067 ± 0.13%
Target-to-target-average – all rods full-up - 1 hr. after shutdown	1.072 ± 0.13%
Target-to-target-average – all rods full-up – 2 hr. after shutdown	1.073 ± 0.13%
Target-to-target-average – all rods full-up – 3 hr. after shutdown	1.080 ± 0.13%

Abbreviations: hr. = hour(s)

Table 4a.5-9
Water Moderator Heating for the 60 Target Configuration

Heating Condition	Fraction of Total Power Heating in Moderator
Neutron heating	[[
Prompt gamma-ray heating	
Total neutron and prompt gamma-ray heating	]]PROP/ECI

Table 4a.5-10
Peak Be Reflector Energy Deposition for the 60-Target, 22.5-cm Configuration

Be Reflector Equivalent Row	Neutron Energy Fraction/cm^3	Prompt Gamma-Ray Energy Fraction/cm^3	Neutron + Gamma-Ray Heating Fraction/cm^3 Peak to Row Peak to Avg
Total reflector ([[ ]]$^{PROP/ECI}$ cm^3)	[[	[[	[[
Row 5 reflector flat			
Row 6 reflector flat			
Row 7 reflector flat			
Row 8 reflector flat	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | cm = centimeter(s) | cm^3 = cubic centimeter(s) | Avg = average

Table 4a.5-11
Axial Peaking Be Reflector Energy Deposition for the Row 5 Flat Location – 5-cm Increments

Be Reflector Axial Position (cm)	Neutron + Gamma-Ray Heating Peaking Factor
[[	[[
]]PROP/ECI	]]PROP/ECI

Abbreviations: Be = beryllium | cm = centimeter(s)

Table 4a.5-12
Control Rod Energy Deposition – Halfway in Core – 96% Enriched Boron

Control Rod Piece	Neutron + Gamma-Ray Heating Fraction/cm^3 1 cm/2 cm
Radius = 0.00 cm – 0.26 cm	4.457E-6 1.628E-6
Radius = 0.26 cm – 0.52 cm	4.442E-6 1.680E-6
Radius = 0.52 cm – 0.78 cm	4.651E-6 1.816E-6
Radius = 0.78 cm – 1.04 cm	5.033E-6 2.170E-6
Radius = 1.04 cm –1.30 cm	**1.544E-5** **1.154E-5**

Abbreviations: cm = centimeter(s) | cm^3 = cubic centimeter(s)

Table 4a.5-13
Be Reflector Reactivity Worth as a Function of Thickness

Reflector Configuration	k_{eff}	Excess Reactivity Difference from Nominal ($)
Nominal 60 targets – [[ ]]$^{PROP/ECI/SRI}$ U per target [[ ]]$^{PROP/ECI}$ cm radial – [[ ]]$^{PROP/ECI}$ cm height + Al above and below reflector height	[[	[[
ΔR = 5 cm		
ΔR = 10 cm		
ΔR = 15 cm	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | k_{eff} = k effective multiplication constant | $ = dollar reactivity unit | g = gram(s) | U = uranium | cm = centimeter(s) | Al = aluminum | ΔR = reflector thickness

Table 4a.5-14
Be Reflector >1 MeV Neutron Flux

Be Reflector Element		>1MeV Neutron Flux (n/cm^2-s-MW)
Average reflector ([[ ]]PROP/ECI cm^3)		[[
Row 5 reflector ([[cm^3)	]]PROP/ECI	
Row 6 reflector ([[cm^3)	]]PROP/ECI	
Row 7 reflector ([[cm^3)	]]PROP/ECI	
Row 8 reflector ([[cm^3)	]]PROP/ECI	]]PROP/ECI

Abbreviations: Be = beryllium | MeV = million electron volts| n/cm^2-s-MW = neutrons per square centimeter per megawatt-second | cm^3= cubic centimeter(s)

Table 4a.5-15
Peak Be Reflector >1 MeV Neutron Flux

Be Reflector Element	>1MeV Neutron Flux (n/cm^2-s-MW) Peak/Row Avg
Row 5 reflector flat location	[[
Row 6 reflector flat location	
Row 7 reflector flat location	
Row 8 reflector flat location	]]PROP/ECI

Abbreviations: Be = beryllium | MeV = million electron volts| n/cm^2-s-MW = neutrons per square centimeter per megawatt-second | cm^3 = cubic centimeter(s)

Table 4a.5-16
Be Reflector He Production

Be Reflector Element		Be-9 (n,2n) => 2He (He/MW-s)	Be-9 (n,α) => 2He (He/MW-s)
Total ([[cm^3)	]]$^{PROP/ECI}$	[[	[[
Row 5 reflector ([[ ]]$^{PROP/ECI}$ cm^3)			
Row 6 reflector ([[ ]]$^{PROP/ECI}$ cm^3)			
Row 7 reflector ([[ ]]$^{PROP/ECI}$ cm^3)			
Row 8 reflector ([[ ]]$^{PROP/ECI}$ cm^3)		]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | He = helium | Be-9 = beryllium-9 | n = neutron | α = alpha particle | MW-s = megawatt-second | cm^3 = cubic centimeter(s)

Table 4a.5-17
Peak Be Reflector He Production

Be Reflector Element	Be-9 (n,2n) => 2He (He/MW-s) Peak/Row Avg	Be-9 (n,α) => 2He (He/MW-s) Peak/Row Avg
Row 5 reflector flat ([[ ]]$^{PROP/ECI}$ cm^3)	[[	[[
Row 6 reflector flat ([[ ]]$^{PROP/ECI}$ cm^3)		
Row 7 reflector flat ([[ ]]$^{PROP/ECI}$ cm^3)		
Row 8 reflector flat ([[ ]]$^{PROP/ECI}$ cm^3)	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | He = helium | Be-9 = beryllium-9 | n = neutron | α = alpha particle | MW-s = megawatt-second | Avg = average | cm^3 = cubic centimeter(s)

Table 4a.5-18
Control Rod He Production

Control Rod Type and Position	He Production Rate (He moles/MW-s)
Enriched boron – halfway in core	1.80E-9
Enriched boron – 15 cm out of core	6.58E-10

Abbreviations: He = helium | MW-s = megawatt-second | cm = centimeter(s)

4a.6 THERMAL-HYDRAULIC DESIGN

This section describes the thermal-hydraulic parameters and characteristics of the all-target reactor core. The results for the analysis for the baseline core design are presented. An operating envelope is established under which the all-target reactor can be operated safely at steady-state conditions. Transient analyses related to thermal-hydraulic performance are presented in Chapter 13a.

The results include a thermal analysis of the targets, reflector matrix, and control rods; an analysis of the natural circulation flow in the core; and CHF calculations of the target cladding. The baseline reactor configuration, as described in Sections 4a.2 and 4a.5, is analyzed. The configuration represents a point design that is representative of a full production scenario that is capable of meeting or exceeding the current U.S. demand for Mo-99. The steady-state operating power level for the baseline configuration is 1.8 MWt with an average target power of 30 kWt.

4a.6.1 THERMAL-HYDRAULIC DESIGN BASIS

The following DC applies to the thermal-hydraulic design:

- DC 6, Reactor Design: The reactor core and associated downcomer and chimney are designed with appropriate margin to ensure that the target heat flux and fuel foil temperature are within acceptable design limits during normal operation, anticipated operational occurrences, and accident conditions.

Fission products are retained in the reactor by the fuel matrix and the cladding. The fuel matrix and the cladding must remain intact during normal, routine, full-power operations and under anticipated transient events to ensure that a release of fission products is prevented. The thermal-hydraulic design is based on maintaining the fuel matrix and the cladding in a condition such that they remain effective fission product barriers for all operating conditions. Under normal operations and anticipated transients, the fuel matrix must remain (with an appropriate safety margin) below the melting point, or any eutectic melting point, and the CHF must not be exceeded for the cladding.

The targets are designed for effective heat transfer under steady-state operating conditions. To effectively cool the targets, the fuel is formed as a foil that covers a large area with intimate contact between the inner and outer cladding material. Equal flow channel areas are maintained within the inner and outer regions of the target, as shown in Figure 4a.5-1, to allow for the same coolant mass flux to be maintained throughout the core. A chimney above the core is used to maintain a defined volume of heated water and a defined buoyancy pressure head. Flow restrictions are minimized in the upper and lower grid plate structure. By design, a large inherent heat capacity does not exist in the target geometry.

The Be reflector matrix is also cooled by the water coolant in the core shroud. The chimney buoyancy pressure head is used in the reflector region to establish coolant flow. The Be material maintains both a large thermal conductivity and heat capacity.

4a.6.2 THERMAL-HYDRAULIC DESIGN DESCRIPTION

The targets, control rods, and Be reflector are cooled by natural circulation flow. The water in the core region and chimney is less dense compared to the water on the outside of the

core/reflector shroud or in the downcomer. The pressure differential between the water in the core and chimney and the water outside of the core region creates the natural circulation flow condition within the core and reflector regions. The flow area of the chimney is significantly greater than for the core region (greater than a factor of 10). When the flow exits the chimney, it mixes with the bulk pool water. The bulk pool water is maintained at a lower temperature than the exit chimney temperature. The bulk pool water is cooled by removing the water from the upper region of the pool, cooling it though heat exchangers, and replacing it in the downcomer. The primary/secondary reactor cooling system is described in Chapter 5a. The year-round dry climate in Lea County, New Mexico, allows for effective evaporative cooling of the secondary water coolant such that the primary coolant temperature can be maintained at or near 20°C (68°F).

The heat is removed from the surface of a target through subcooled nucleate boiling. The water in the coolant channel remains below the saturation temperature for the given pool water depth. Small steam bubbles form on the cladding and either collapse or break away from the surface and collapse in the coolant channel, because the bulk water temperature is below the saturation temperature. This is an effective method for removing the heat from the cladding surfaces.

4a.6.3 ANALYTICAL TOOLS AND METHODS

Two types of analyses are performed on the core to encompass the range of thermal-hydraulic issues. A thermal analysis of the fuel matrix and cladding is performed to determine the peak fuel temperature for different power levels and power distributions found in Section 4a.5. A thermal-hydraulic analysis is performed to determine the heat flux and exit flow channel temperatures for different power levels and inlet conditions. Using conservative assumptions in the analyses, a steady-state operating envelope is established for safe operation of the reactor. Similar analyses are performed for the Be reflector and the control rods.

Because the geometry for the targets, control rods, and reflector is relatively simple, analytical thermal analysis can be used to determine the peak fuel temperature, peak control rod temperature, and peak reflector temperature as a function of the reactor power level at steady-state conditions. More complex numerical solutions are also determined using the finite element analysis heat transfer modules in the SOLIDWORKS code. The assumptions, conditions, uncertainties, and parameters analyzed are discussed and the results presented in the following subsections.

Because the geometry for the targets in the core is simple, a one-dimensional (1-D) fluid flow analysis is adequate to determine the coolant channel mass flux and exit temperature and cladding temperatures under steady-state conditions. The steady-state 1-D thermal-hydraulic analysis was performed using the code MASSFLR (Mass Flow Rate) and the CHF code CHFR (Critical Heat Flux Ratio). MASSFLR was used to determine the coolant flow rate and exit temperature as a function of the target power level and coolant inlet temperature under steady-state conditions. The code numerically solves the coupled continuity, momentum, and energy equations as applied to a 1-D, incompressible, subcooled, vertical flow channel. CHFR was used to determine the CHF conditions using an empirical correlation developed at the University of New Mexico (UNM) (Rao and El Genk, 1994). The assumptions, conditions, uncertainties, and parameters analyzed are discussed with the results in the following subsections.

4a.6.4 TARGET THERMAL ANALYSIS

The geometry for the target is simple and straightforward. Because heating occurs between two equal thickness Al cladding cylinders and the fuel is in contact with the cladding, a 1-D analytical solution to the steady-state heat equation can be readily determined assuming that the thermal conductivity does not have significant temperature dependence. The cladding boundary was fixed at 130°C (266°F), which represents a typical wall temperature under subcooled nucleate boiling conditions, presented in later sections.

It is assumed that all the energy from fission is uniformly deposited in the fuel foil, because the range of a fission fragment in U metal is a few microns. Some fission fragments escape the coating surface and deposit their energy directly into the Ni recoil barrier. However, excluding the Ni recoil barrier in the calculations has negligible effects on the results because the Ni recoil barrier is very thin.

The dimensions used in the analysis are as follows:

- Target cladding outer radius – 1.28 cm (0.504 in.), thickness – [[ ]]$^{PROP/ECI/SRI}$).
- Target length (fuel) – 40.0 cm (15.75 in.).
- U foil thickness – [[ ]]$^{PROP/ECI/SRI}$.
- Target cladding inner radius – 1.10 cm (0.433 in.), Thickness – [[ ]]$^{PROP/ECI/SRI}$.

The cladding is Al-6061 and the fuel foil U metal. The foil is full density U metal in contact with the cladding with no gap. The Ni recoil barrier foil is very thin and is assumed to have no effect on the heat transfer. The fuel foil thickness is assumed to be uniform along the length of the target. The axial peaking factor used in the analysis was 1.25. The thermal conductivity used in the analysis was 1.77 watts (W)/cm-K for Al and 0.275 W/cm-K for U metal.

Because the target is a thin-walled cylinder, cylindrical or rectangular coordinates could be used to solve the heat equation. The analytical results are slightly more accurate using cylindrical coordinates. Solving the 1-D steady-state heat equation with uniform heating results in the following analytical expression at the center of the fuel thickness (peak temperature of the fuel).

$$T_{fuel}(a) = \frac{\dot{q}'''}{4k_{fuel}}(b^2-a^2) + \frac{\dot{q}'''}{2k_{fuel}}a^2 \ln\frac{a}{b} + T_{clad}(b) \qquad \text{(Equation 4a.6-1)}$$

where:

$\dot{q}'''$ is the volumetric heat rate (W/cm^3)

k is the conductivity (W/cm-K)

$T_{clad}(b)$ is the temperature at the fuel/cladding interface (°C)

a is the radius to half of the fuel thickness (1.19 cm)

b is the inner radius of the outer cladding (1.20 cm)

For the cladding, the peak occurs at the fuel/cladding interface with the solution:

$$T_{clad}(b) = \frac{\dot{q}'''}{2k_{clad}} (b^2-a^2) \ ln\frac{c}{b} + T_{clad}(c) \quad \text{(Equation 4a.6-2)}$$

where:

$T_{clad}(c)$ is the temperature at the cladding surface boundary (130°C)

c is the outer radius of the outer cladding (1.28 cm)

In terms of the heat flux on the surface of the cladding, $\dot{q}''$, the equations can be rewritten as:

$$T_{fuel}(a) = \frac{\dot{q}''}{2k_{fuel}} c + \frac{\dot{q}'' c\ a^2}{(b^2-a^2)k_{fuel}} ln\frac{a}{b} + T_{clad}(b) \quad \text{(Equation 4a.6-3)}$$

$$T_{clad}(b) = \frac{\dot{q}''}{k_{clad}} c\ ln\frac{c}{b} + T_{clad}(c) \quad \text{(Equation 4a.6-4)}$$

The analysis was performed using 30 kWt as the average target power. The total surface area of the target cladding over the fuel length of 40 cm (15.7 cm) is [[ ]]PROP/ECI. The average heat flux for the average target is 50 W/cm^2. Using an axial peaking factor of 1.25, the heat flux at the peak axial location for a target is 62.5 W/cm^2.

The results are shown in Table 4a.6-1. Using the peak heat flux of 62.5 W/cm^2, the peak cladding temperature is calculated to be [[ ]]PROP/ECI larger than the cladding surface temperature. The peak fuel temperature is calculated to be [[ ]]PROP/ECI larger than the peak cladding temperature. Assuming that the cladding surface temperature is 130°C (266°F), the peak fuel temperature is 134.1°C (273.4°F). This result assumes that there is no thermal resistance between the fuel foil and the cladding. That is, there is intimate contacts between the U foil and Al cladding. Thermal resistance is a function of several parameters including the surface roughness, contact pressure, and surface hardness. Although theoretical analysis can be performed to determine thermal resistance, experimental diffusivity measurements for hydroformed prototypic targets must be performed in the future, allowing for an accurate determination of the contact thermal resistance for a target. It is expected that the thermal resistance between the U foil and the Al cladding increases the U foil centerline temperature by tens of degrees Celsius.

SOLIDWORKS calculations were performed using a 3-D model of the target using the same assumptions. Both the inner and outer surface cladding temperatures were held fixed at 130°C (266°F). The analysis was performed at the axial peak location with a peaking factor of 1.25. The results are shown in Figure 4a.6-1. As expected for this simplistic geometry, the results agree closely with the analytical solution.

The results of this analysis show that the peak temperature in the target is dominated by the external surface cladding temperature. With intimate contact between the U foil and the cladding, the peak fuel temperature is only a few °C greater than the cladding surface

temperature. Again, the analysis assumes that there is no thermal resistance between the U foil and the cladding.

4a.6.5 REFLECTOR ELEMENT THERMAL ANALYSIS

A thermal analysis is performed for the reflector matrix. The reflector geometry is somewhat complex with the sawtooth triangular inner shape as presented in Subsection 4a.2.3. Both an analytical and a SOLIDWORKS model were performed to determine the temperatures in the reflector at full power (1.8 MWt). For the analytical model, a 1-D rectangular solution to the steady-state heat equation was used and the row and peak axial energy deposition factors were applied as presented in Subsection 4a.5.3.7.2. For the SOLIDWORKS model, the 3-D geometry was modeled with the peak row energy deposition (Table 4a.5-10) and the axial energy density profile (Table 4a.5-11).

The dimensions used in the analytical analysis are as follows:

- Reflector matrix – Be metal – four regions.
- [[ ]]$^{PROP/ECI}$ thickness each region.
- [[ ]]$^{PROP/ECI}$ thickness total.

The reflector is Be metal with a density of 1.85 g/cm^3. The thermal conductivity used in the analysis was 2.0 W/cm-K for Be.

Solving the 1-D steady-state heat equation with a uniform heating within a region results in the following analytical expression for rectangular coordinates.

$$T(x_i) = \frac{\dot{q}'''_{i+1}}{2\,k_{i+1}}\left(x_{i+1}^2 - x_i^2\right) + \frac{\dot{q}'''_{i+1}}{k_{i+1}}\,x_i^2\left(1 - \frac{x_{i+1}}{x_i}\right) + \frac{\dot{Q}''_i}{k_{i+1}}\,x_i\left(\frac{x_{i+1}}{x_i} - 1\right) + T(x_{i+1})$$

(Equation 4a.6-5)

where

$\dot{q}'''_{i+1}$ is the volumetric heat rate (W/cm^3) at the *i+1* th boundary

$\dot{Q}''_i$ is the heat flux (W/cm^2) at the *i* th boundary

k_{i+1} is the conductivity (W/cm-K) at the *i+1* th boundary

$T(x_{i+1})$ is the temperature at the *i+1* th boundary (°C)

x_i and x_{i+1} are the interface positions (cm)

Table 4a.6-2 presents the reflector peak heating rates using a reactor power level of 1.8 MWt, the peak row energy deposition (Table 4a.5-10) and the axial energy deposition profile (Table 4a.5-11).

Two cases were analyzed for the Be reflector:

- Reflector with forced flow convection cooling on the core side of the reflector and an insulated boundary on the back side of the reflector.
- Reflector with forced flow convection cooling on the core side of the reflector and free flow convection cooling on the back side of the reflector.

The 1-D analytical results are presented in Table 4a.6-3. A boundary temperature was calculated to be [[ ]]PROP/ECI, using a flow convection heat transfer coefficient of 0.20 W/cm^2-K and a bulk water coolant temperature of 50°C (122°F). The cooling on the back side of the reflector for case 2 is assumed to be free flow convection. The heat transfer coefficient is assumed to be 0.02 W/cm^2-K.

The results show that the temperature in the Be reflector is dominated by the convection cooling at the core-side surface of the reflector. For the core side only cooling case, the temperature of the surface of the reflector is [[ ]]PROP/ECI. The peak temperature is found at the back-side surface of the reflector because this surface was treated as an insulated boundary. The temperature at the back surface is [[ ]]PROP/ECI larger than the inner surface. For the core side and back side cooling case, the peak temperature in the reflector is found near the back side because the heat transfer coefficient used is a free convection value. For this case, the peak temperature is [[ ]]PROP/ECI larger than the front surface.

SOLIDWORKS calculations were performed using a 3-D model of the reflector. For this model, the axial energy deposition profile (Table 4a.5-11) was used with the row energy deposition heating. The upper half of the Be reflector was modeled, starting at the core axial centerline. The results are shown in Figure 4a.6-2 for the core side only cooling and in Figure 4a.6-3 for the core and back side cooling. The peak temperature is found at the back side of the reflector and the core axial centerline. For the core side only cooling, the peak temperature is [[ ]]PROP/ECI. For the core and back side cooling, the peak temperature is [[ ]]PROP/ECI. The peak temperatures are found to be less than for the analytical model because heat transfer occurs in all three dimensions.

4a.6.6 CONTROL ROD THERMAL ANALYSIS

A thermal analysis is performed for the control rod poison section, with the control rod located halfway into the core and the core operating at full power. The control rod geometry is simple, but the heating profile is somewhat complex. Because the B-10 has a large neutron cross-section, the inner regions of the B_4C pellets are self-shielded as described in Subsection 4a.5.3.7.3. For the analytical model, a 1-D cylindrical solution to the steady-state heat equation was used and the radial energy deposition factors were applied as presented in Subsection 4a.5.3.7.

The dimensions used in the analytical analysis are shown in Figure 4a.6-4. The control rod poison is B_4C with a density of 1.80 g/cm^3. The thermal conductivity used in the analysis was 0.36 W/cm-K for B_4C.

Solving the 1-D steady-state heat equation with a uniform heating source region results in the following analytical expression for cylindrical coordinates:

$$T(r_i) = \frac{\dot{q}'''_{i+1}}{4\,k_{i+1}}\left(r_{i+1}^2 - r_i^2\right) + \frac{\dot{q}'''_{i+1}}{2\,k_{i+1}}\,r_i^2\,ln\frac{r_i}{r_{i+1}} + \frac{\dot{Q}'_i}{2\pi\,k_{i+1}}\,ln\frac{r_{i+1}}{r_i} + T(r_{i+1})$$

(Equation 4a.6-6)

The 1-D steady-state heat equation without a heat source results in the following analytical expression for cylindrical coordinates:

$$T(r_i) = \frac{\dot{Q}'_i}{2\pi\,k_{i+1}}\,ln\frac{r_{i+1}}{r_i} + T(r_{i+1})$$

(Equation 4a.6-7)

where:

$\dot{q}'''_{i+1}$ is the volumetric heat rate (W/cm^3) at the *i+1* th boundary

$\dot{Q}''_i$ is the heat flux (W/cm^2) at the *i* th boundary

k_{i+1} is the conductivity (W/cm-K) at the *i+1* th boundary

$T(r_{i+1})$ is the temperature at the *i+1* th boundary (°C)

r_i and r_{i+1} are the interface radii (cm)

Table 4a.6-4 presents the control rod heating rates with the control rod halfway in the core, a reactor power level of 1.8 MWt, and using the energy deposition values for 96 percent enriched B (Table 4a.5-12).

Table 4a.6-5 shows the 1-D analytical results. For this analysis, Al-6061 was used for both the inner container and the cladding. Because the control rod poison sections are backfilled with He during the manufacturing process, He gas conductivity was used in the gaps. The gaps were 0.008 cm (0.003 in.), which represents a slip fit. The 1-D analysis was performed for both the 0 – 1 cm and 1 – 2 cm regions of the control rod with no axial heat transfer. Because the 0 – 1 cm regions have the highest heat rate, these temperatures are the peak values in this analysis. The temperatures calculated from the 1-D analytical model are conservative because there is a significant amount of heat transfer in the axial direction of the poison section. A cladding boundary temperature was calculated to be between [[ ]]$^{PROP/ECI}$, using a flow convection heat transfer coefficient of 0.10 W/cm^2-K and a bulk water coolant temperature of 50°C (122°F).

The results show that the peak temperature in the B_4C is at the radial centerline of the rod. For the 1 – 2 cm position, the peak temperature is [[ ]]$^{PROP/ECI}$ for the 96 percent enriched B. For the 0 – 1 cm position, the peak temperature is [[ ]]$^{PROP/ECI}$. The 1-D results indicate that the peak temperatures in the B_4C pellets are relatively low using a 0.008 cm (0.003 in.) gap with He gas fill.

4a.6.7 TARGET ELEMENT FLOW CHANNEL ANALYSIS

The ability to cool the targets at steady-state operating conditions and anticipated events is extremely important in establishing a safety basis for the reactor design. The heat flux that can be maintained from the cladding to the coolant is dependent on the geometry, coolant mass flux, pressure, and inlet coolant temperature. For natural circulation flow conditions, the coolant mass flux is dependent on the flow geometry, friction losses, minor losses, and the coolant buoyancy. A margin of two to the CHF must be maintained for normal full-power operations and anticipated events.

The all-target reactor maintains a relatively low coolant pressure. In Lea County, New Mexico, the average atmospheric pressure is 0.088 MPa (12.9 psi). The water depth in the reactor pool from reactor coolant overflow level to the top of the upper core grid plate is [[ ]]$^{PROP/ECI}$, resulting in an additional pressure of 0.070 MPa (10.3 psi). The absolute pressure at the top of the core grid is 0.158 MPa (23.2 psia). At this pressure, the T_{sat} at the top of the core grid is 113°C (235°F). Because the all-target reactor operates at conditions below the saturated water temperature, there is no bulk boiling or quality in the coolant channels of the reactor. In fact, exceeding the saturation condition in the coolant channels is to be avoided. Because the coolant flow is driven by natural circulation, and because of the low operating pressure, the onset of bulk boiling leads to significant voiding (vapor bubbles) at a relatively small quality value in the coolant channels. This is illustrated in Figure 4a.6-5, where for only a 2 percent quality, the void fraction is greater than 90 percent at 0.1 MPa (14.7 psia) (El-Wakil, 1962). At higher pressures, the voiding effects become less severe.

For the all-target reactor operating at 1.8 MWt, heat is removed from the cladding by subcooled nucleate boiling. Steam bubbles form on the surface of the cladding and break off into the coolant channel. Because the coolant is less than the saturation temperature, the bubbles collapse in the coolant channel. If the coolant temperature increases and approaches the saturation temperature, more bubbles are formed and the effective void fraction in the coolant channel increases. This effect is illustrated in Figure 4a.6-6 for atmospheric pressure conditions with flow (Evangelisti and Lupoli, 1969). The effective void fraction is a function of the pressure, coolant mass flux, coolant temperature, and heat flux. A larger heat flux, higher coolant temperature, or lower coolant mass flux increases the effective void fraction. Figure 4a.6-6 is from experimental work for a heat flux of 45 W/cm^2 and a mass flux of 61 g/s-cm^2, which is representative of the all-target reactor conditions at full power. For the all-target reactor, the expected core exit water temperature is below 70°C (158°F), 43°C (77.4°F) below T_{sat}. According to Figure 4a.6-6, the effective void fraction is near zero. The effective voiding in the coolant channels increases the buoyancy effects of the coolant but, more importantly, has a large negative effect on reactivity.

For the all-target reactor, if exit channel saturation conditions are approached, flow oscillations begin to occur due to bubbles, formed by subcooled boiling, coalescing and forming larger voids within the channel. If saturation conditions are exceeded, bulk boiling begins in the channel. Steam bubbles formed by nucleate boiling no longer collapse as they break away from the cladding surface. The developing two-phase flow presents a significantly greater flow resistance, decreasing the channel mass flow rate and increasing the vapor generation until the increased buoyancy of the two-phase coolant causes the remaining liquid in the channel to be ejected. The subsequent influx of cooler water causes a delay period until the cycle repeats. These flow oscillations are sometimes referred to as “chugging” and are a natural consequence of convection cooling at these conditions. The voiding effect has a strong negative effect on the reactivity, because the voiding occurs at the exit of the core and allows for a much larger

neutron leakage. Power oscillations and power dropouts occur because the negative reactivity is not maintained as cooler water enters the channels.

Because the reactor core is positioned near the bottom of an open pool, the pressure at the channel exit is the ambient atmospheric pressure plus the pressure of the pool water column. The saturation temperature is a function of the reactor pool water level. This effect is shown in Figure 4a.6-7 for a local atmospheric pressure of 0.088 MPa (12.9 psia), a pool water density of 0.988 g/cm^3 (50°C [122°F]), and a maximum water column height above the channel exit of [[ ]]$^{PROP/ECI}$. At the nominal, full water level of the pool, the T_{sat} is 113°C (235°F). The value for T_{sat} is not a critical parameter for safety, but instead is used in flow analysis to determine the transition from single-phase heat transfer to subcooled nucleate boiling.

The flow analysis was performed for the target channel using a simple 1-D, single-phase model. No cross flow between flow channels was included in the model. There are four assumptions used in the model:

- Flow is assumed to be 1-D, with no cross flow. Because cross flow results in a greater coolant mass in the flow channel, allowing for greater heat transfer from the fuel to the coolant, assuming no cross flow leads to conservative results.
- Minor entrance and exit losses are conservatively bounded using suitable minor loss coefficients.
- Chimney effects due to the hot coolant water exiting the core are included in the model.
- Additional buoyancy effects due to the subcooled nucleate boiling void fraction within the channel are neglected in the model, which is conservative.

The thermal-hydraulic parameters used in the model are shown in Figure 4a.3-2 and Table 4a.6-6 for the target and cooling channel. Because the flow channel area inside of the target element is the same as the effective flow channel area on the outside of the target, the results of the analysis are applicable to both. Analysis was performed for the outer flow channel. The target heat flux is assumed to be the same for inside the target as outside the target. The flow equation used to determine the channel flow rate is the modified Bernoulli equation for 1-D, fully developed flow at steady-state conditions. The pressure drop in each target flow region must equal the overall buoyancy pressure increase.

$$\Delta P_{bouy} = \Delta P_{ent} + \Delta P_{exit} + \Delta P_{fric-l} + \Delta P_{fric-h} + \Delta P_{fric-u} + \Delta P_{acc} \qquad \text{(Equation 4a.6-8)}$$

where:

ΔP_{bouy} is the pressure increase due the temperature difference of the water, and subsequent coolant density change, from the downcomer to the chimney

ΔP_{ent} is the entrance loss from the lower grid plate

ΔP_{exit} is the exit loss from the upper grid plate

ΔP_{fric} is the friction loss from the lower unheated region of the target, heated region of the target, and upper unheated region of the target

ΔP_{acc} is acceleration loss

Using minor loss coefficients and friction factor multipliers (Rao and El Genk, 1994; Bird, Stewart, & Lightfoot, 1960, Fox and McDonald, 1973), the pressure drop terms are calculated as follows:

$$\Delta P_{bouy} = (\rho_{inlet} - \rho_{exit})\ g\ \Delta H_{ch} \quad \text{(Equation 4a.6-9)}$$

$$\Delta P_{ent} = K_{ent} \frac{\dot{m}^2}{2\,\rho_{inlet}\,A^2} \qquad K_{ent} = 0.5 \quad \text{(Equation 4a.6-10)}$$

$$\Delta P_{exit} = K_{exit} \frac{\dot{m}^2}{2\,\rho_{exit}\,A^2} \qquad K_{exit} = 1.0 \quad \text{(Equation 4a.6-11)}$$

$$\Delta P_{fric} = f_m \frac{L}{D_{equ}} \frac{\dot{m}^2}{2\,\rho_{ch}\,A^2} \quad \text{(Equation 4a.6-12)}$$

$$\Delta P_{acc} = \left(\frac{1}{\rho_{exit}} - \frac{1}{\rho_{inlet}}\right) \frac{\dot{m}^2}{A^2} \quad \text{(Equation 4a.6-13)}$$

where:

ρ is the water density in the respective location in the coolant channel

g is the gravitational constant

ΔH_{ch} is the chimney height

$\dot{m}$ is the mass flow rate in the channel

A is the channel flow area

L is the channel length

D_{eq} is the equivalent diameter of the flow channel

f_m is the Moody friction factor

The Moody friction factor is defined as

$$f_m = \frac{64}{Re} \qquad Re < 2100 \quad \text{(Equation 4a.6-14)}$$

$$f_m = 0.186\,Re^{0.2} \qquad Re > 2100 \quad \text{(Equation 4a.6-15)}$$

where Re is the Reynolds number.

The two unknowns in the equations are the coolant channel mass flow rate ($\dot{m}$) and the exit coolant temperature that determines the coolant exit density (ρ_{exit}). Using the energy equation:

$$P = \dot{m}\ C_p\ (T_{exit} - T_{inlet}) \quad \text{(Equation 4a.6-16)}$$

where:

P is the power in half of the target

C_p is the coolant heat capacity

T_{exit} is the exit coolant temperature

T_{inlet} is the coolant inlet temperature

The two equations (Equations 4a.6-8 and 4a.6-16) can be iterated to find the channel mass flow rate and the coolant exit temperature.

Along with the determination of the mass flow rate and exit temperature, the target cladding temperature can be calculated using an axial target peaking factor and calculated heat transfer coefficient. The heat transfer coefficient is modeled as follows:

for single-phase heat transfer => $T_{wall} < T_{sat}$, Kim-El Genk correlation (Rao and El Genk, 1994)

$$T_{wall} = \frac{\dot{q}^{''} D_{eq}}{Nu\ k} + T_{sat} \quad \text{(Equation 4a.6-17)}$$

$$Nu = 0.272\ Ra^{0.25} \quad \text{(Equation 4a.6-18)}$$

where:

$\dot{q}^{''}$ is the heat flux

k is the water coolant thermal conductivity

Nu is the Nusselt number

Ra is the Rayleigh number

for subcooled boiling heat transfer => $T_{wall} > T_{sat}$, Thom correlation (Rohsenow, Hartnett, & Cho, 1998):

$$T_{wall} = 22.5\ \dot{q}^{''} e^{-p/8.7} + T_{sat} \quad \text{(Equation 4a.6-19)}$$

where:

T is the temperature (°C)

$\dot{q}^{''}$ is the heat flux (MW/m^2)

p is the pressure (MPa)

Calculations were performed for inlet coolant temperature conditions ranging from 10°C (50°F) to 100°C (212°F), for different chimney heights, and target power levels. The axial heating profile used was from the MCNP results in Subsection 4a.5.3.5. The mass flow rate and coolant exit temperature were calculated, along with the cladding temperature, as a function of axial position on the target. The mass flow rate was then used in the CHF correlation calculation to determine the CHF at the specified condition.

Table 4a.6-7 shows the pressure drop results for a [[ ]]PROP/ECI chimney, inlet water temperature of 20°C (68°F), and a target power of 30 kWt (15 kWt inner, 15 kWt outer). Using the loss coefficients presented, the channel flow rate is calculated to be [[ ]]PROP/ECI, equivalent to a mass flux of [[ ]]PROP/ECI. The water channel exit temperature is calculated to be [[ ]]PROP/ECI.

The pressure drop in the flow channel is almost equally divided between the entrance and exit losses and the friction losses. The acceleration loss is small. The [[ ]]PROP/ECI chimney has a significant effect on increasing the flow rate and decreasing the exit temperature. For a chimney height of [[ ]]PROP/ECI, the flow rate and exit temperatures are [[ ]]PROP/ECI, respectively; for [[ ]]PROP/ECI; and for no chimney, [[ ]]PROP/ECI.

As the reactor power increases from zero power to full power, single-phase convection heat transfer cools the target cladding until the surface temperature reaches the saturation temperature of the coolant. At this point, localized subcooled nucleate boiling begins to occur on the cladding surface. Because the coolant bulk enthalpy has not reached saturation, these bubbles collapse almost immediately on the cladding or after detaching from the surface. Fully developed, subcooled boiling is reached when the cladding temperature is greater than about 10°C (18°F) above the coolant saturation temperature. Because this is a highly efficient heat transfer mechanism, the heat transfer coefficient is large. The cladding temperature does not increase significantly with an increase in target power.

Figure 4a.6-8 shows the effects of subcooled boiling on the cladding temperature as a function of target power. The heat transfer regime transitions from single-phase convection to subcooled nucleate boiling between [[ ]]PROP/ECI kWt and [[ ]]PROP/ECI kWt. At [[ ]]PROP/ECI kWt and below, the target is cooled by single-phase convection. At higher power levels, nucleate boiling begins at the axial midplane where the heat flux is the largest. The cladding surface temperature reaches the value of about 10°C (18°F) above the coolant T_{sat}. The cladding surface temperature is below [[ ]]PROP/ECI for fuel target power levels less than 30 kWt. At 30 kWt, the subcooled boiling heat transfer coefficient at the peak axial location is [[ ]]PROP/ECI W/cm^2-K. At [[ ]]PROP/ECI kWt, the single-phase convection heat transfer coefficient at the peak axial location is 1.11 W/cm^2-K. A [[ ]]PROP/ECI -kWt change in the target power above 30 kWt only results in a [[ ]]PROP/ECI change in the cladding temperature.

Figure 4a.6-9 shows the calculated channel mass flow rate and mass flux for a target at 30 kWt and a [[ )]]PROP/ECI chimney as a function of the water coolant channel inlet temperature. The channel mass flow rate increases from [[ ]]PROP/ECI. For a 60-target core, the total mass flow rate through the core is [[ ]]PROP/ECI for an inlet temperature of 20°C (68°F).

The calculated mass flow rates are used with the target element and flow channel parameters to determine the CHF conditions. Empirical correlations developed at UNM (Rao and El Genk, 1994), the Bernath correlation (Tong, 1965), and the CHF Lookup Tables (Groeneveld, Chen, & Doan, 1986; Groeneveld et al., 1996; 2007) with a K factor of 0.5, were used to determine the target power required to reach the CHF as a function of the inlet coolant temperature. The results are presented in Figure 4a.6-10. Also shown in the figure are the results for the element power required to reach exit channel saturation conditions. The 30 kWt and 60 kWt power levels are identified for reference, assuming that 30 kWt is the average target operating power level and 60 kWt is the average target power required to maintain a CHF margin of two. At 30 kWt, the exit channel saturation condition is reached with an inlet temperature greater than 90°C (194°F).

The Bernath correlation and CHF Lookup Tables have been used in the past to predict the CHF for TRIGA [Training, Research, Isotopes, General Atomics]-type reactors (Feldman, 2007). However, comparison of these correlations with more recent experimental work for low flow, low pressure conditions in annuli and TRIGA fuel forms show that the correlations significantly over-predict the CHF (Rao and El Genk, 1994). The Bernath correlation is not appropriate for use under the flow and pressure conditions in the all-target reactor. The flow rates are below the lower range of the correlation by about a factor of three.

The UNM El-Genk correlation is found to agree well with other experimental work for flow in annuli and TRIGA type fuel forms at low flow, low pressure conditions (Yang et al., 2012) and is used for the all-target reactor analysis. For a 30-kWt target with a [[ ]]$^{PROP/ECI}$ chimney, a minimum critical heat flux ratio (MCHFR) of two can be maintained for inlet temperatures of up to about [[ ]]$^{PROP/ECI}$.

The following results can be concluded from the analysis of the baseline core:

- At a target power of 40 kWt and a [[ ]]$^{PROP/ECI}$ chimney, saturation conditions are not exceeded for an inlet coolant temperature of 90°C (194°F) or less.
- At an inlet coolant temperature of 45°C (113°F) or less, the MCHFR is greater than two for a target element power of up to 40 kWt. A value of 40 kWt represents a target-to-target average peaking factor of 1.18 calculated in Subsection 4a.5.3.5, and a reactor power of 2.0 MWt, 11 percent larger than the nominal operating power of 1.8 MWt for a 60-target core configuration. These values can be used to establish a TS limiting safety system setting and limiting condition for operation.
- At an inlet coolant temperature of 45°C (113°F), the CHF is exceeded at a target power of 80 kWt. These values can be used to establish a TS Safety Limit.

Operating an average target at 30 kWt with a [[ ]]$^{PROP/ECI}$ chimney and an inlet temperature of up to 45°C (133°F) allows for a sufficient margin to exist from the CHF conditions at steady-state power, including core target-to-target-average peaking factors.

4a.6.8 REFLECTOR/CONTROL ROD FLOW CHANNEL ANALYSIS

Flow calculations, similar to those for the target, can be performed for the control rods, reflector follower rods, and reflector matrix. The thermal-hydraulic parameters used in the calculation are shown in Table 4a.6-8 for the model shown in Figure 4a.6-11 for the control rod and cooling channel.

The cooling requirements for the control rods, reflector follower rods, and reflector matrix are much less rigorous than for a target because the heating in the control rods and reflector is relatively small compared to a target. The maximum heat flux from the poison section of a control rod when halfway in the core at 1.8 MWt is [[ ]]$^{PROP/ECI}$ W/cm^2 (from Table 4a.6-5). For the surface of the reflector next to the core, the maximum heat flux is [[ ]]$^{PROP/ECI}$ W/cm^2 (from Table 4a.6-3). These are maximum heat flux values at the peak axial locations. For the control rod, reflector follower, and the reflector, the heat flux decreases significantly in the axial direction. With the control rod 15 cm (5.9 in.) above the centerline of the core, the maximum heat flux in the poison section is [[ ]]$^{PROP/ECI}$ W/cm^2.

The coolant flow rate in the flow channel around the control rod/reflector follower and the face of the Be reflector is governed primarily by the buoyancy pressure differential from the cold water in the downcomer and the hot water in the chimney. This buoyancy pressure differential, caused by the different water densities in these regions, establishes the flow rate in the channel surrounding the control rod/reflector follower and the inner surface of the Be reflector.

Calculations were performed for inlet coolant temperature conditions at 20°C (68°F) for a chimney height of [[ ]]$^{PROP/ECI}$. The exit temperature in the chimney was maintained at [[ ]]$^{PROP/ECI}$, which represents the chimney temperature for the target calculation at 30 kWt.

The channel exit temperature, coolant channel mass flow rate, and cladding/surface temperatures are shown in Table 4a.6-9 for a heat flux of 5 W/cm^2 and 10 W/cm^2, consistent with the maximum heat flux that could be expected for the control rod, reflector rod, or reflector matrix. For this analysis, it was assumed that the complete 60 cm (23.6 in.) heated length was at these heating values. Because the flow regime is in the laminar-transitional phase through the coolant channel and no axial profile was used in the calculation, the cladding temperature is found to be linearly increasing from the entrance to the exit of the flow channel. No flow mixing with the target region of the core was included in the calculation, although it is expected that flow mixing would be significant for the control rod channel. Flow mixing enhances the cooling capability of the targets and control rod.

The values for the heat transfer coefficients calculated (column 4) are consistent with those used in the thermal analysis performed in Subsections 4a.6.5 and 4a.6.6.

Table 4a.6-1
Target Temperature for an Average Target with an Axial Peaking Factor of 1.25 Using the Analytical Solution

Location	Temperature (°C) ΔT (°C)
Al cladding – boundary	130 --
Al cladding/U foil – interface	132.9 2.9
U foil – centerline	**134.1** 1.2

Abbreviations: °C = degrees Celsius | ΔT = difference in temperature | Al = aluminum | U = uranium

Table 4a.6-2
Peak (Row and Axial) Be Reflector Heating Rates at 1.8 MWt

Reflector Dimension		Volumetric Heat Rate (W/cm^3)	Linear Heat Rate (W/cm^2)
X = [[	]]$^{PROP/ECI}$ – outside reflector	[[	[[
X = [[	]] $^{PROP/ECI}$		
X = [[	]]$^{PROP/ECI}$		
X = [[near core	]]$^{PROP/ECI}$ – inside reflector	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | MWt = megawatt-thermal | W = watt(s) | cm^3= cubic centimeter | cm^2 = square centimeter(s)

Table 4a.6-3
Peak Be Reflector Temperature

	Temperature (°C) ΔT (°C)	
	Core Side Cooling Only	**Core and Back Side Cooling**
Boundary – core side 50°C water temperature h = [[ ]]$^{PROP/ECI}$ W/cm^2-K	[[	[[
Be – region 1/2 interface		
Be – region 2/3 interface		
Be – region 3/4 interface		
Boundary – back side Insulated or 50°C water, h = [[ ]]$^{PROP/ECI}$ W/cm^2-K	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be = beryllium | °C = degrees Celsius | ΔT = difference in temperature | h = convective heat transfer coefficient | W = watt(s) | cm^2 = square centimeter(s) | K = Kelvin

Table 4a.6-4
Control Rod Energy Deposition at 1.8 MW, Halfway in Core – 96% B-10

Control Rod Piece	Volumetric Heat Rate at 1 cm (W/cm^3)	Linear Heat Rate at 1 cm (W/cm)	Volumetric Heat Rate at 2 cm (W/cm^3)	Linear Heat Rate at 2 cm (W/cm)
Radius = 0.00 cm - 0.26 cm	[[	[[	[[	[[
Radius = 0.26 cm - 0.52 cm				
Radius = 0.52 cm - 0.78 cm				
Radius = 0.78 cm - 1.04 cm				
Radius = 1.04 cm -1.30 cm	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: MW = megawatt(s) | B-10 = boron-10 | cm = centimeter(s) | W = watt(s) | cm^3 = cubic centimeter(s)

Table 4a.6-5
Control Rod Temperature – Halfway in Core

	Temperature (°C) ΔT (°C) 96% Enriched Boron	
Location	**0 – 1 cm**	**1 – 2 cm**
Al cladding – boundary 50°C, h = 0.1 W/cm^2-K	[[	[[
He gas gap/Al cladding – interface		
Al container/He gas gap – interface		
He gas gap/Al container – interface		
B_4C/He gas gap – interface		
B_4C – region 4/5 interface		
B_4C – region 3/4 interface		
B_4C – region 2/3 interface		
B_4C – region 1/2 interface		
B_4C – centerline	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: °C = degrees Celsius | ΔT = difference in temperature | cm = centimeter(s) | h = convective heat transfer coefficient | W = watt(s) | cm^2 = square centimeter(s) | K = Kelvin | He = helium | Al = aluminum | B_4C = boron carbide

Table 4a.6-6
Flow Channel Thermal-Hydraulic Parameters for the Target Element

Target element outer diameter	2.56 cm
Pitch	3.08 cm
Flow channel heated length	40.00 cm
Flow channel lower unheated length	10.00 cm
Flow channel upper unheated length	10.00 cm
Flow channel area	3.07 cm^2
Chimney height	[[ ]]PROP/ECI

Abbreviations: cm = centimeter(s)

Table 4a.6-7
Flow Channel Pressure Drop for a 30 kW Target Element, 20°C Inlet Water Temperature, [[ ]]$^{PROP/ECI}$ Chimney Height

Effect	Pressure Drop (Pa)
Chimney buoyancy Exit temperature = 46.1°C, channel flow rate = [[ ]]$^{PROP/ECI}$ kg/s	[[
Heated channel buoyancy (no voiding effects included)	
Entrance loss	
Friction loss – lower unheated region	
Friction loss – heated region	
Friction loss – upper unheated region	
Acceleration loss	
Exit loss	
Total	]]$^{PROP/ECI}$

Abbreviations: kW = kilowatt(s) | °C = degrees Celsius | m = meter(s) | kg/s = kilograms per second

Table 4a.6-8
Flow Channel Thermal-Hydraulic Parameters for the Be Reflector Follower Rod/Control Rod

Reflector element outer diameter	2.92 cm
Pitch	3.08 cm
Flow channel heated length	60.00 cm
Flow channel lower unheated length	10.00 cm
Flow channel upper unheated length	10.00 cm
Flow channel area	1.52 cm^2
Chimney height	[[ ]]PROP/ECI

Abbreviations: Be = beryllium | cm = centimeter(s) | cm^2 = square centimeter(s)

Table 4a.6-9
Control Rod/Be Reflector Rod Coolant Channel Exit Temperature, Mass Flow Rate, and Cladding/Surface Temperature as a Function of the Heat Flux

Heat Flux (W/cm^2)	Coolant Channel Exit Temperature (°C)	Coolant Channel Mass Flow Rate (kg/s)	Heat Transfer Coefficient Range (W/cm^2-K)	Cladding/ Surface Temperature Range (°C)
5	[[	[[	[[	[[
10	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: Be= beryllium | W/cm^2 = watts per square centimeter | °C = degrees Celsius | kg/s = kilograms per second | K = Kelvin | cm = centimeter(s)

4a.7 BURNUP CONSIDERATIONS

This section describes burnup issues related to the target, reflector matrix, and control rod poison section.

4a.7.1 TARGET BURNUP

The target design bases include maximizing the heat transfer to the coolant and maintaining the fission products within the fuel matrix and the cladding boundary. It is essential that during the lifecycle of a target, the mechanical contact between the U foil and the Al cladding remains intact. Gap formations between the fuel foil and the cladding can reduce the heat transfer from the fuel foil to the cladding to unacceptable levels and risk the integrity of the target. If the U foil remains in contact with one side of the cladding, the heat transfer is sufficient to cool the target at full-power operations.

The target must be able to withstand routine temperature cycling to 130°C (266°F) for the cladding, radiation exposure, and burnup with no degradation in performance. Target temperature cycling has no effect on target performance. Residual stresses from the target fabrication maintain the U foil in compression. After fabrication, the inner Al cladding is in compression and the outer Al cladding in tension. Because the inner and outer cladding materials are the same and the heat rate is the same, the thermal expansion of the inner and outer cladding is also the same value. For Al, the thermal expansion coefficient is 24E-6 per °C. For 130°C (266°F), the expansion of the cladding is approximately 0.3 percent or a radius change of about 0.004 cm (1.5 mils). The U foil is about [[ ]]$^{PROP/ECI/SRI}$ the thickness of the Al cladding. Expansion and stresses in the target are dominated by the cladding properties. Temperature cycling does not affect the thermal performance of the target.

A 30-kWt target operating for 21 days experiences 0.63 MW-days of burnup or 0.0029 moles of fission events (equivalent to 0.68 g [0.024 oz.] of U-235 fission). This is equivalent to about 0.61 percent heavy metal burnup. From these fissions, 0.00063 moles (0.084 g, 0.003 oz.) of Xe and 0.00011 moles (0.0093 g, 0.0003 oz.) of krypton gas are created. For a target loading of [[ ]]$^{PROP/ECI/SRI}$ of U, this corresponds to about [[ ]]$^{PROP/ECI/SRI}$ in the fuel matrix. At this burnup level, no adverse effects are expected on target performance. Target burnup is limited to 0.75 MW-days.

The target fuel is expected to be recycled and reused as target material. Subsection 4a.5.3.1 describes the reactivity effects of using 15 percent enriched U fuel as opposed to 19.75 percent enriched fuel. It is expected that, on a 14-day irradiation cycle, the fuel goes through 14 cycles to reach an enrichment of 15 percent. To achieve the same reactivity characteristic in the core, the target U foil mass (or thickness) would be required to increase over time from [[ ]]$^{PROP/ECI/SRI}$.

4a.7.2 REFLECTOR MATRIX BURNUP

Be metal reflector matrix radiation damage and He production were discussed in Subsection 4a.5.3.9. The conclusion was that at full power operations, the reflector should last [[ ]]$^{PROP/ECI}$ years, comparing the He production and swelling results to those of the ATR. At the peak He production location, Be atom consumption is 0.7 percent. In terms of burnup due to reactivity changes in the reflector, the amount of Be atoms consumed has no effect on reactivity.

4a.7.3 CONTROL ROD BURNUP

He production and release from the control rod B_4C poison section was discussed in Subsection 4a.5.3.10. The analysis examined the potential stresses on the cladding material assuming a 10 percent He release from the B_4C. The results concluded that, from a cladding pressurization perspective, the lifetime of the control rod poison section is over [[ ]]$^{PROP/ECI}$ years.

Thermal analysis on the control rod B_4C poison section was discussed in Subsections 4a.6.6 and 4a.6.8. Using a B_4C thermal conductivity of 0.36 W/cm-K, a gap of 0.008 cm, and a He backfill, the peak temperature in the B_4C at the centerline is approximately [[ ]]$^{PROP/ECI}$.

There are issues with B_4C pellets when irradiated to high burnup. Significant swelling, He gas release, cracking, and fracturing can occur in B_4C. Also, the thermal conductivity can significantly decrease with increasing burnup. Experimental work performed by Maruyama et al. showed that for both low and high temperature irradiations these effects can be significant (Maruyama et al., 1997). Because the irradiation of the B_4C poison section in the all-target reactor is at relatively low temperatures, the analysis focuses on that portion of the work.

Maruyama et al. report that swelling at low temperatures (< 600°C or 1112°F) is linear with burnup (Maruyama et al., 1997). The swelling rate was found to be 3.5 percent volumetric swelling per 100E26 captures per cubic meter (cap/m^3). 100E26 cap/m^3 is equivalent to 0.0166 moles of He production/cm^3. He gas release was found to be less than 10 percent for irradiation temperatures less than 600°C (1112°F) and burnup up to 100E26 cap/m^3 (0.0166 moles/cm^3). Thermal conductivity was found to decrease significantly as a function of burnup. At 10E26 cap/m^3 (0.00166 moles/cm^3) the thermal conductivity was approximately 0.08 W/cm-K, at 40E26 cap/m^3 (0.0066 moles/cm^3), 0.03 W/cm-K. This is about a factor of 12 decrease from the unirradiated reported value of 0.36 W/cm-K. Cracking was found to begin at 28E26 cap/m3 (0.0046 moles/cm^3) with significant powdering at 129E26 cap/m3 (0.0214 moles/cm^3).

Using the results from Maruyama, et al., it is reasonable to assume that the burnup limit in B_4C at temperatures below 600°C (1112°F) should be 25E26 cap/m^3 (0.0042 moles/cm^3) to avoid cracking of the material and significant swelling (Maruyama, et al., 1997). At this value, the swelling is less than 1 percent and the He release is less than 10 percent. The thermal conductivity is estimated to be 0.04 W/cm-K. Using a thermal conductivity value of 0.04 W/cm-K in the analytical calculations presented in Subsection 4a.6.6, the peak centerline temperature of the B_4C only increases by [[ ]]$^{PROP/ECI}$, which is an acceptable value.

The He production values presented in Subsection 4a.5.3.10 for the 0 – 1 cm end B_4C pellet in the poison section of a control rod are on average [[ ]]$^{PROP/ECI}$, with the control rod halfway inserted into the core and with the reactor operating at 1.8 MWt for 1 year. Assuming a limit of 25E26 cap/m^3 (0.0042 moles He/cm^3), the reactor could be operated for [[ ]]$^{PROP/ECI}$ years. A reasonable limit is [[ ]]$^{PROP/ECI}$ MW-years of operation of the control rods before replacement is necessary.

4a.8 SUMMARY AND CONCLUSIONS

A baseline core configuration for the all-target reactor was presented that allows for operation at 1.8 MWt. Hardware, nuclear, thermal-hydraulic, and mechanical design descriptions were presented with analyses to support steady-state operations at full-power conditions.

The following list summarizes the configurations, conditions, and conclusions that are encompassed by the analyses in this chapter and allow for safe operation of the core configuration in the steady-state mode. Accident and transient conditions are analyzed in Chapter 13a. Proposed parameters for TS are addressed in Chapter 14 and will be finalized in the Operating License Application.

- Targets are annular to allow for cooling on both the inner and outer cladding walls. Target fuel is LEU metal foil with Al cladding. The LEU is 19.75 percent enriched in U-235 or less. Targets have a fuel loading of [[ ]]$^{PROP/ECI/SRI}$ LEU (approximately [[ ]]$^{PROP/ECI/SRI}$ U-235 at 19.75 percent enrichment) for the nominal baseline configuration.
- The baseline configuration is 60 targets operating at a steady-state full power of 1.8 MWt. Average power level is 30 kWt per target element.
- Target-to-target average peaking factor is 1.05 with the control and safety rods fully withdrawn. With the control rods fully inserted, the target-to-target-average peaking factor is 1.18. Axial peaking factor for a target element is 1.23.
- For a target power of 39 kW (target-to-target average peaking factor of 1.3), the MCHFR is greater than two for a core inlet temperature of 50°C (122°F) or less. This target power allows for a significant margin compared to the expected maximum peaking factor of 1.18.
- Excess reactivity required for operating at 1.8 MWt for a clean-cold core is [[ ]]$^{PROP/ECI}$, to allow for Xe and fission product poisoning, burnup, and temperature feedback effects.
- An adequate shutdown margin (>$0.50) is maintained for the reactor using four Be-followed control rods and one Al-followed safety rod, even with any one rod stuck in the full-out position.
- Targets are limited to a burnup of 0.75 MW-days.

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Figure 4a.2-1
All-Target Reactor Core

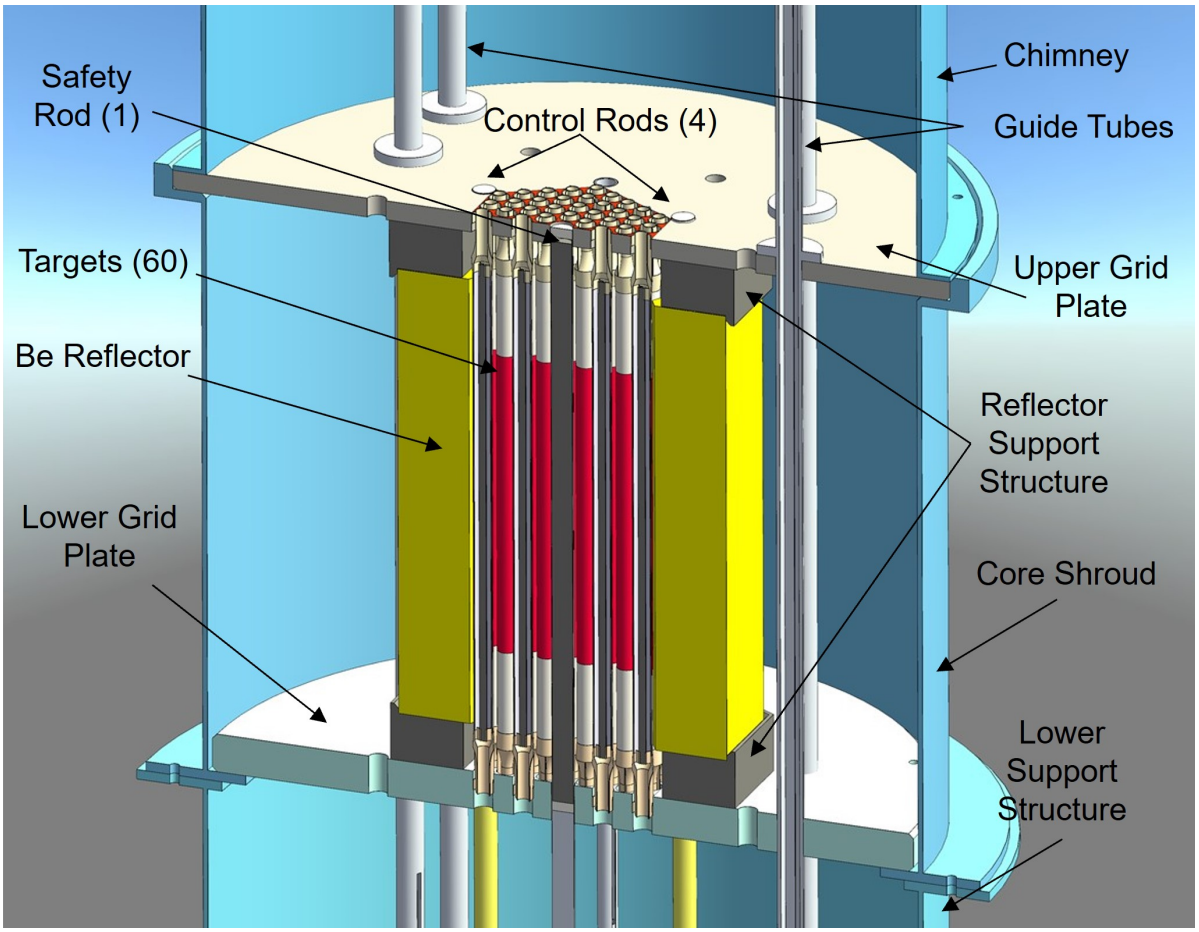


Figure 4a.2-2
Pool Liner and Bridge Structure

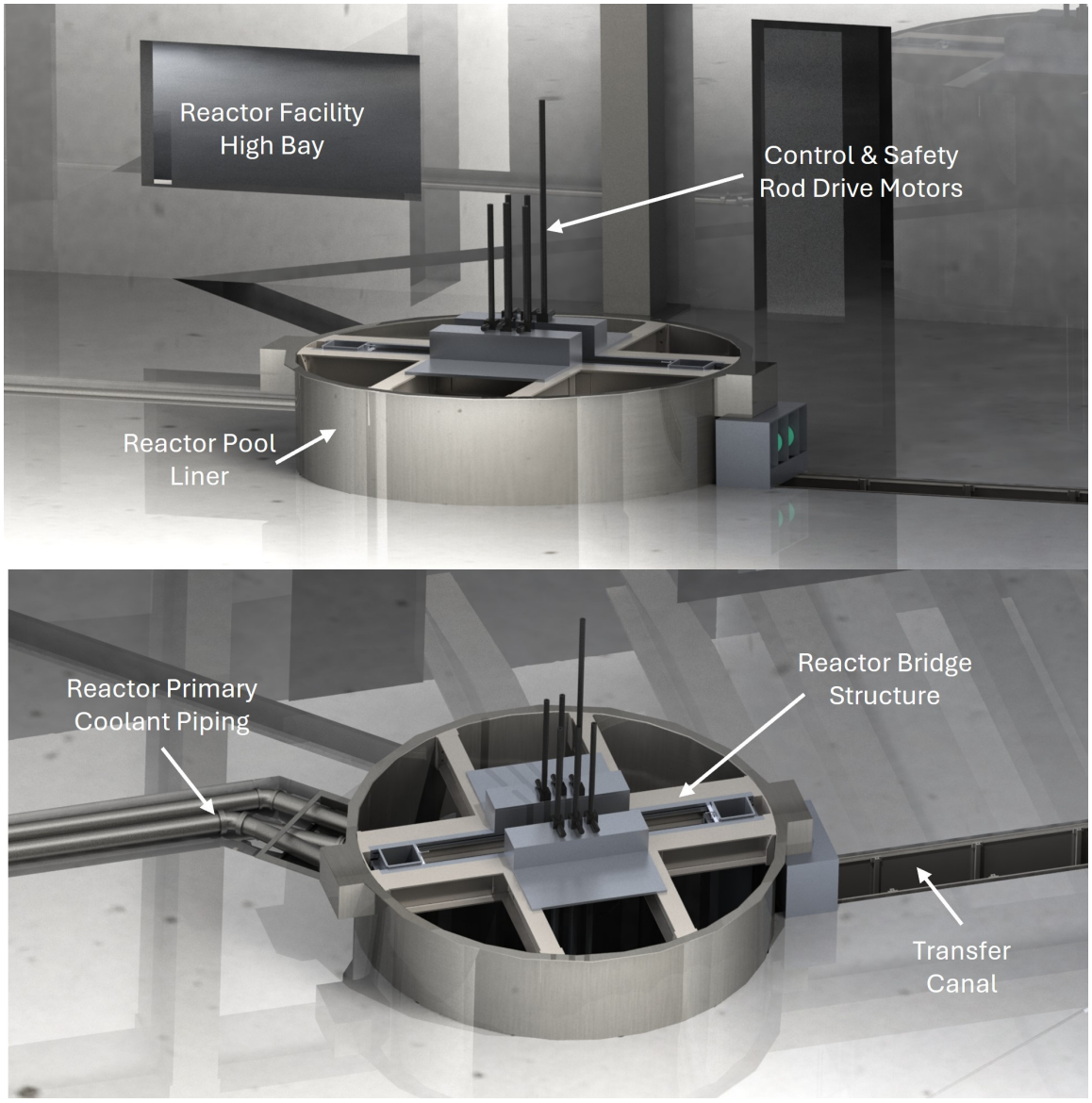


Figure 4a.2-3
All-Target Reactor Pool and Core

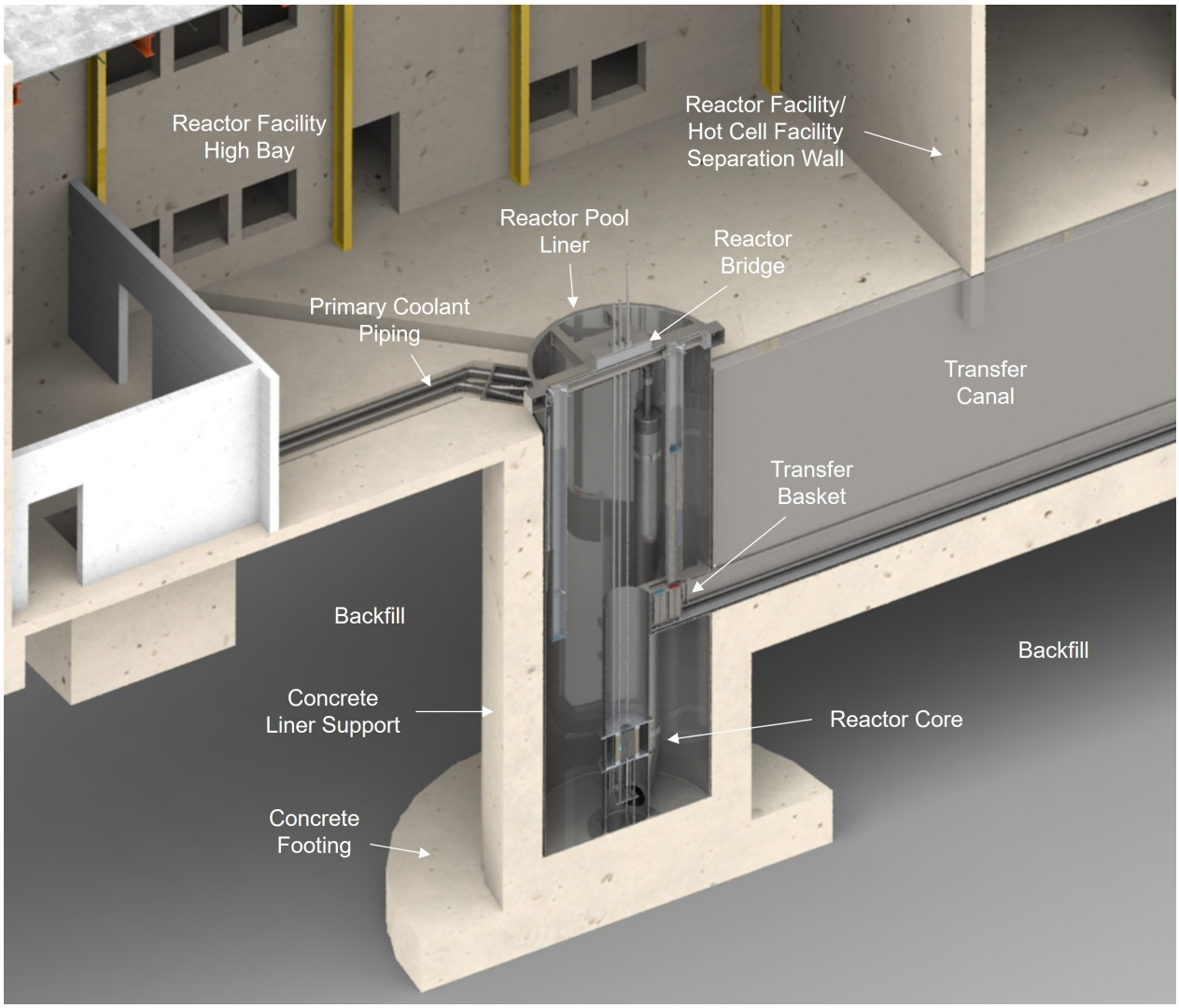


Figure 4a.2-4
Section View of the All-Target Reactor Pool and Core

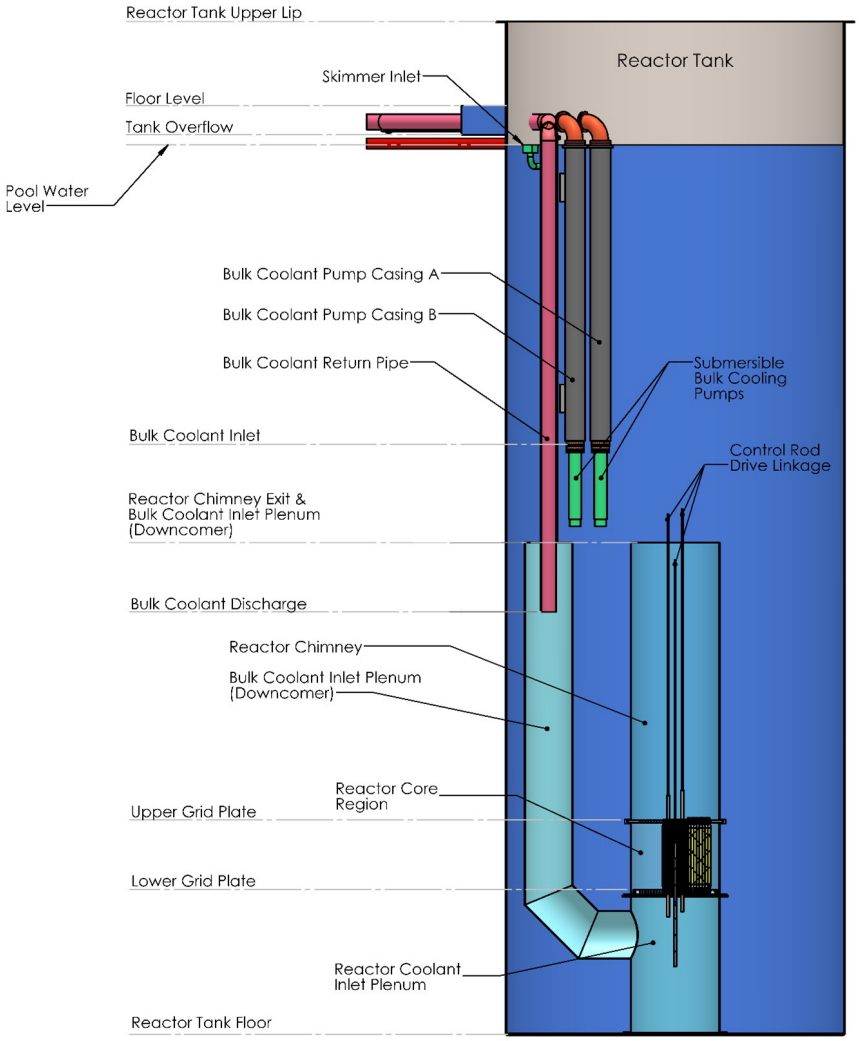
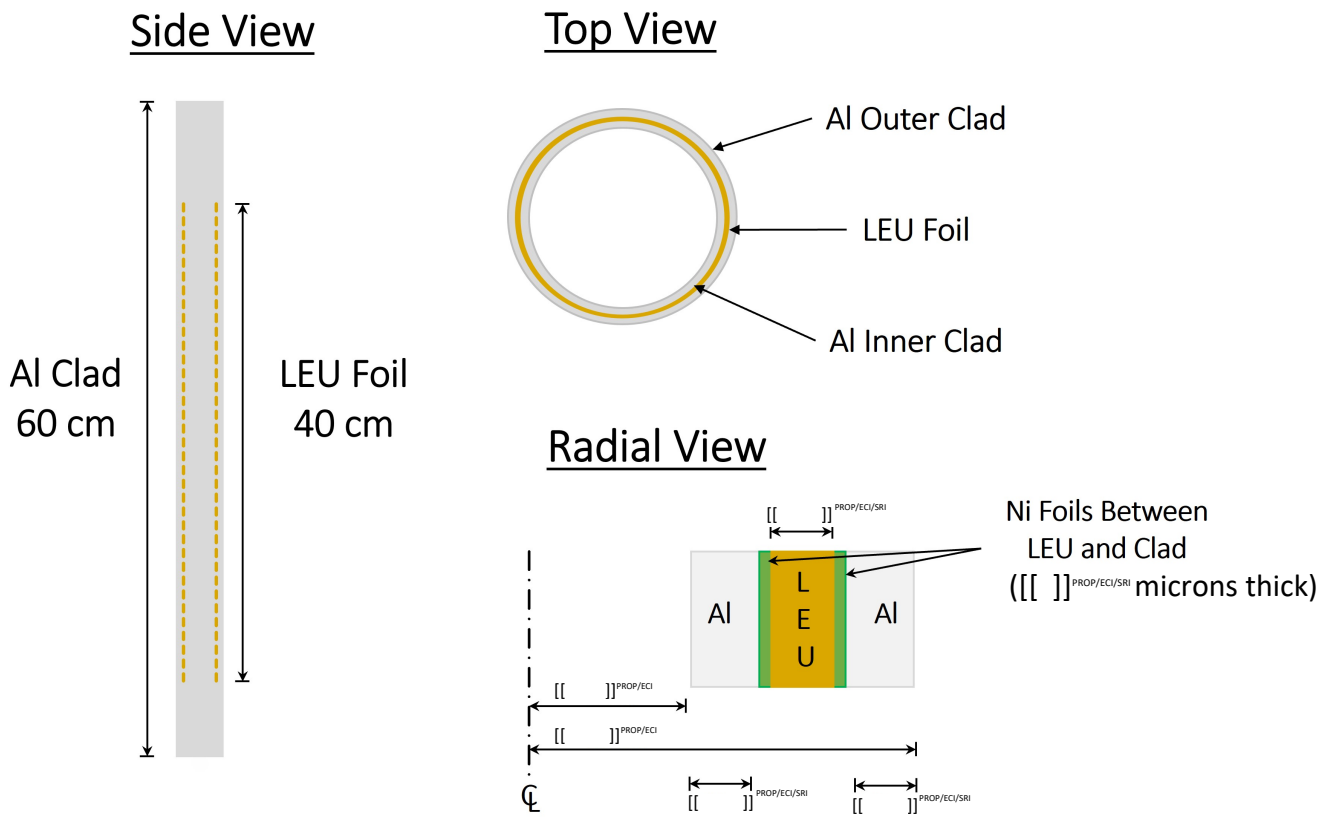


Figure 4a.2-5
Target Nominal Description



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Target with Handling Fixtures

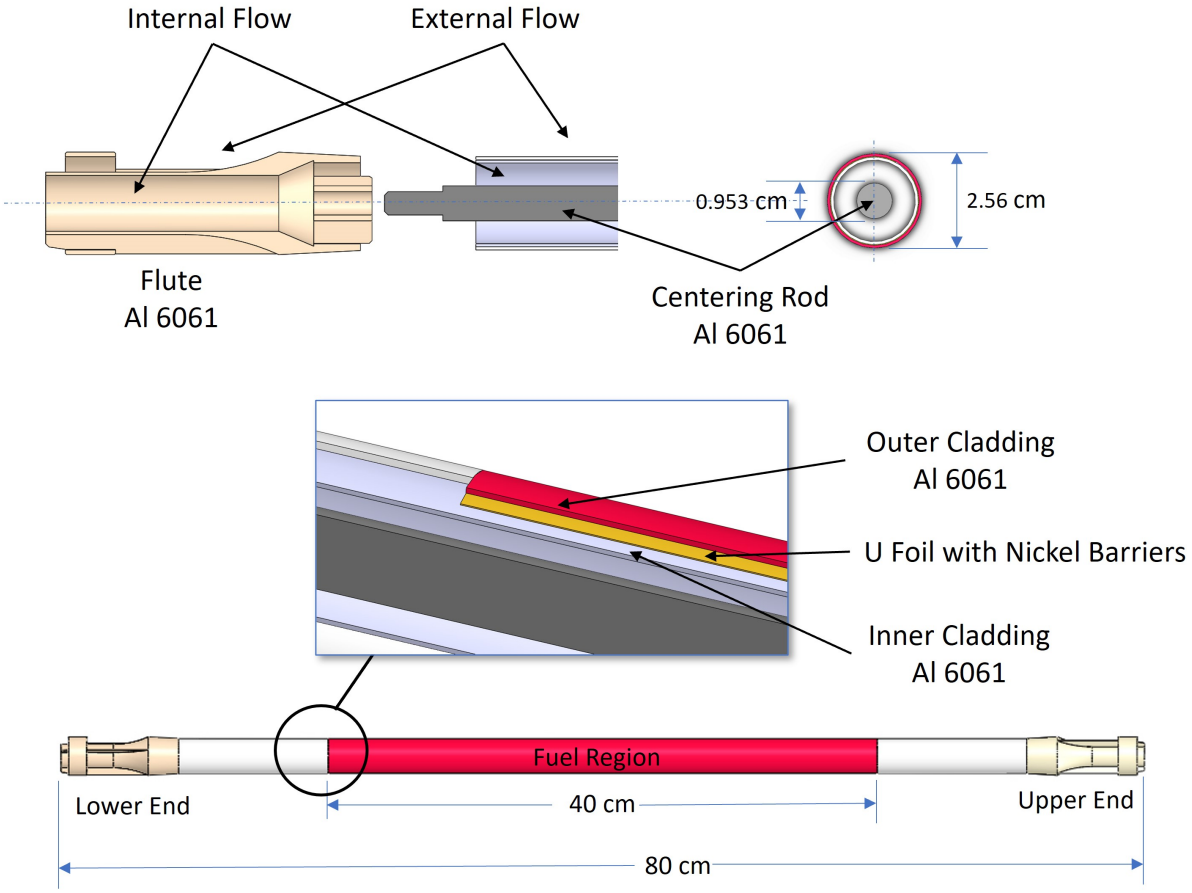
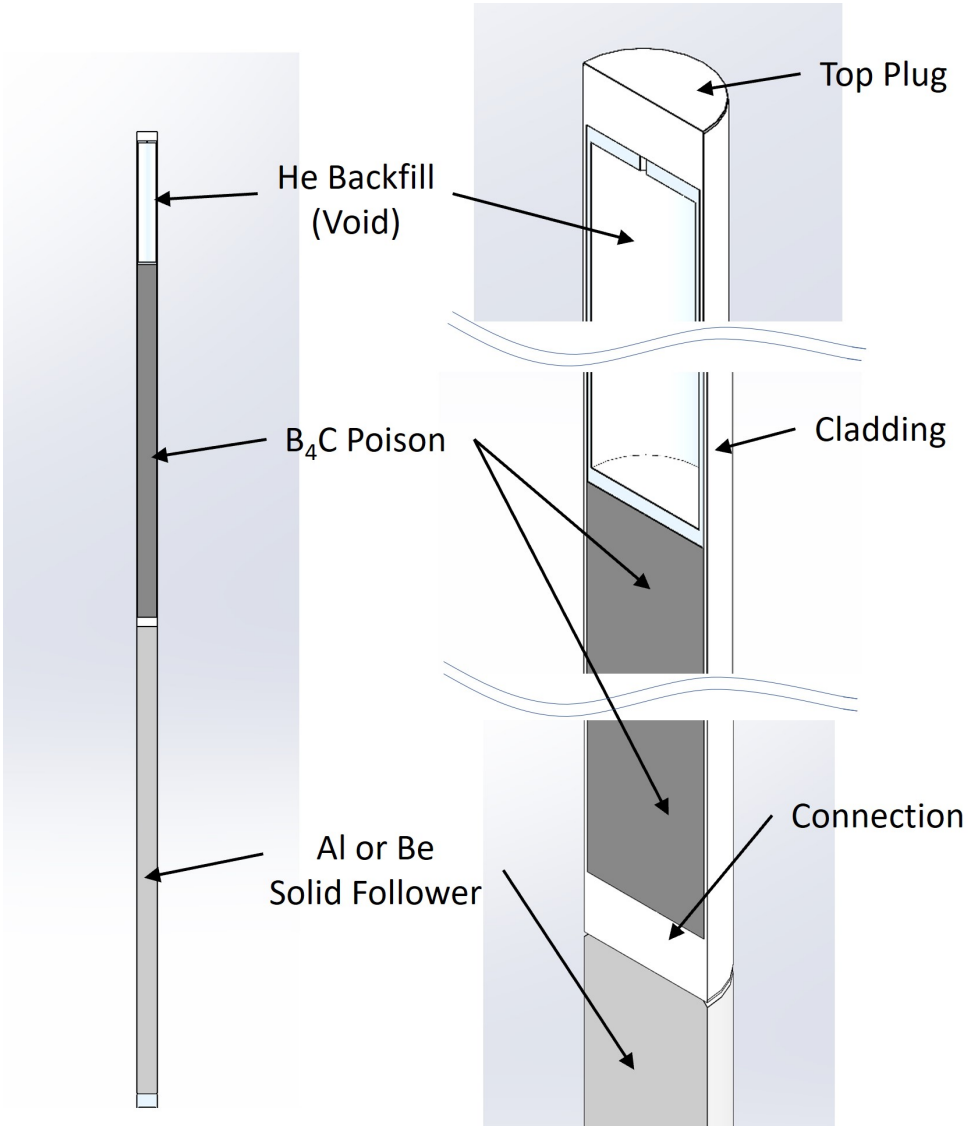


Figure 4a.2-7
Control/Safety Rod Schematic



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All-Target Core Configuration Baseline

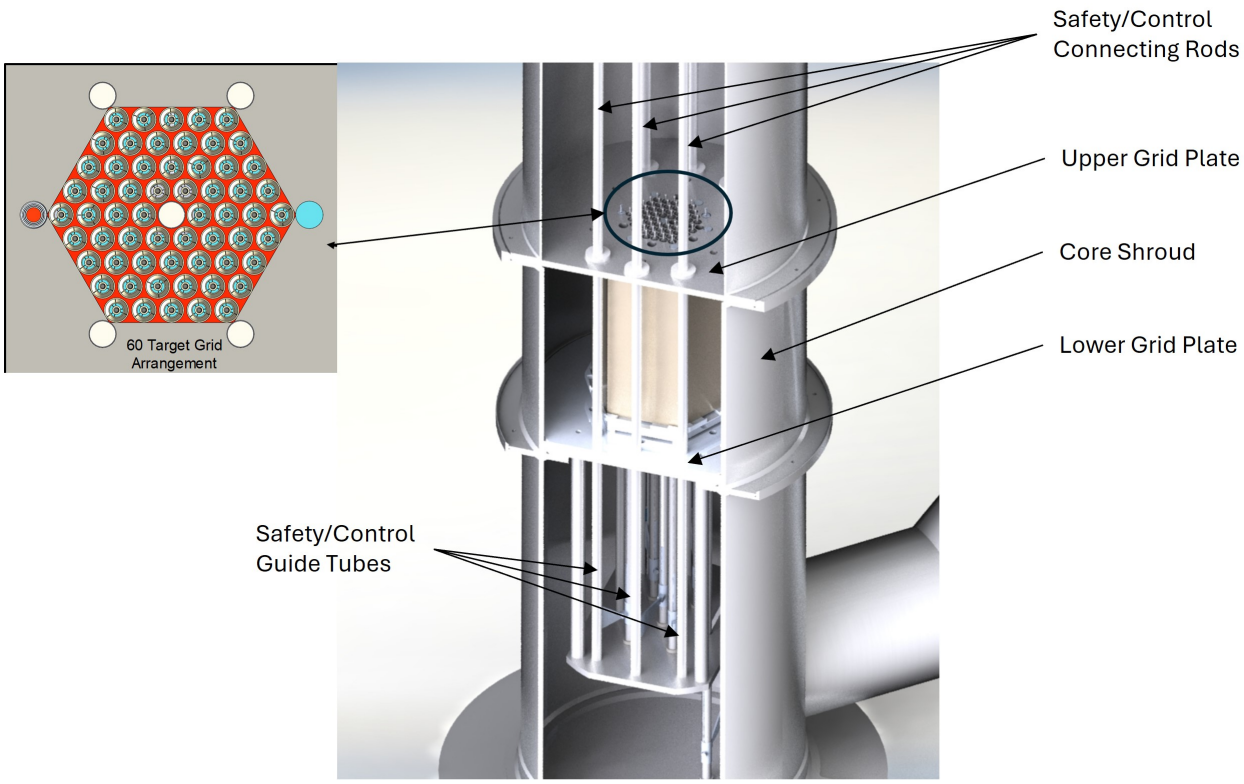


Figure 4a.2-9
Control and Safety Rod Drive Mechanism Shown in the Full-Down Position

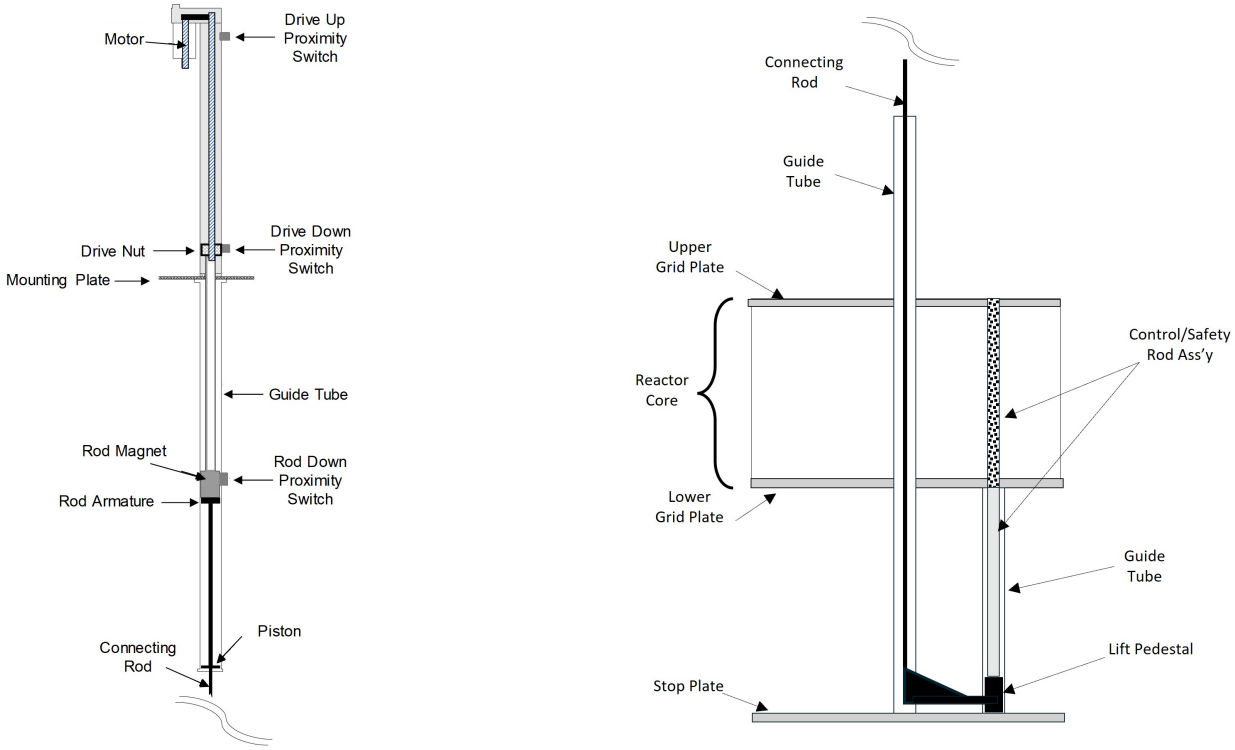


Figure 4a.2-10
Be Metal Reflector Matrix

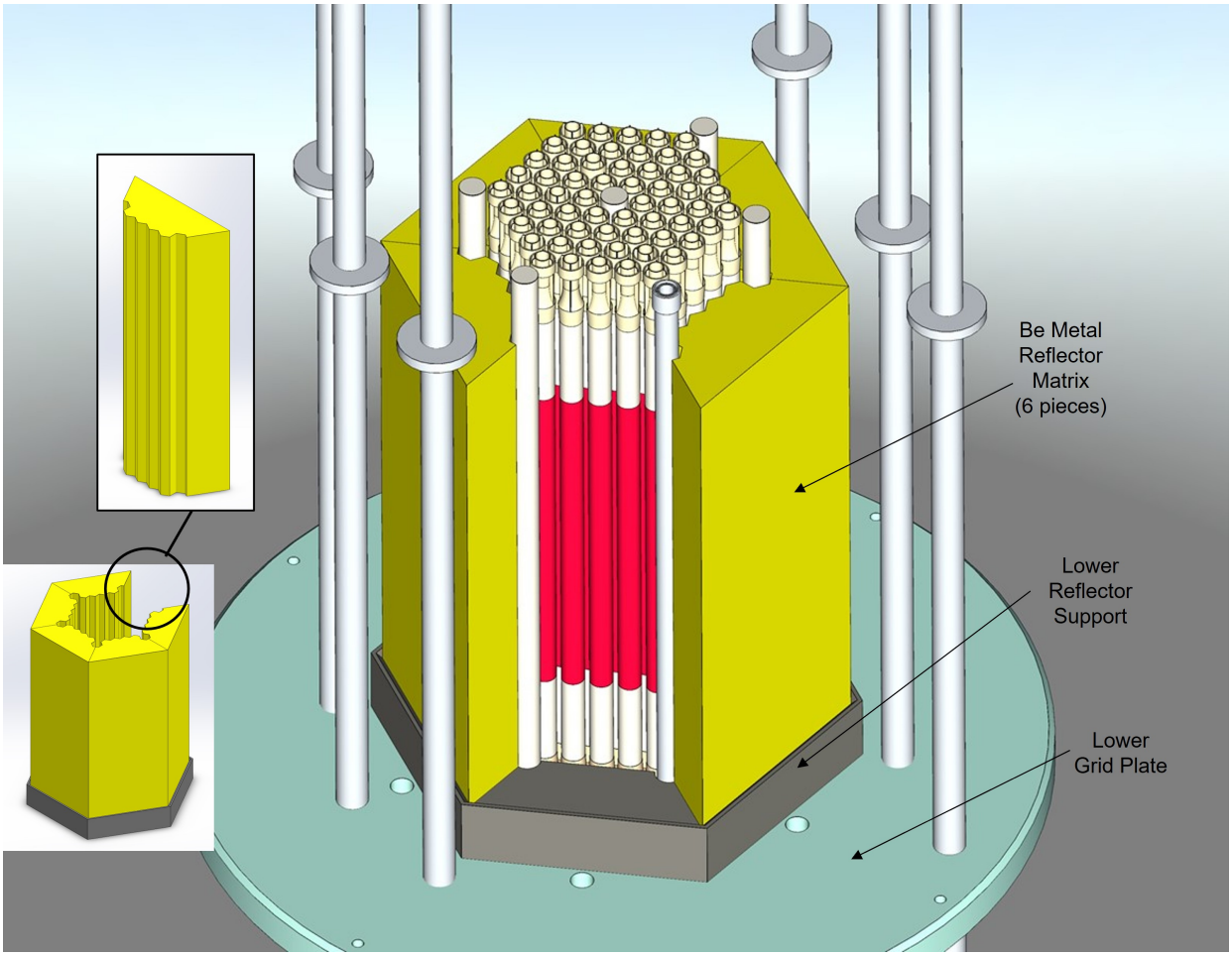


Figure 4a.2-11
Core Support Structure

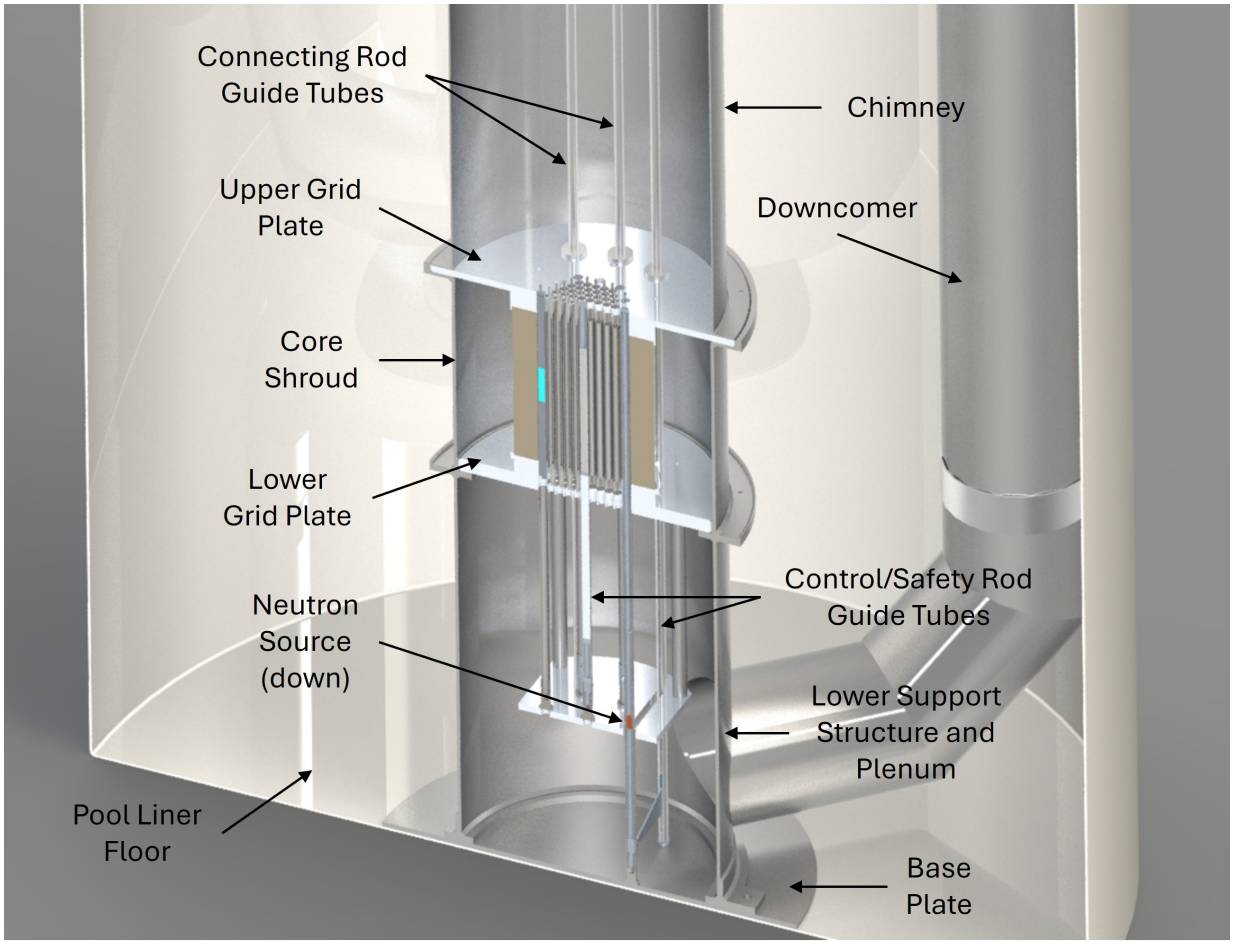


Figure 4a.3-1
Elevation View of the Reactor Pool – Showing Materials and Cooling Lines

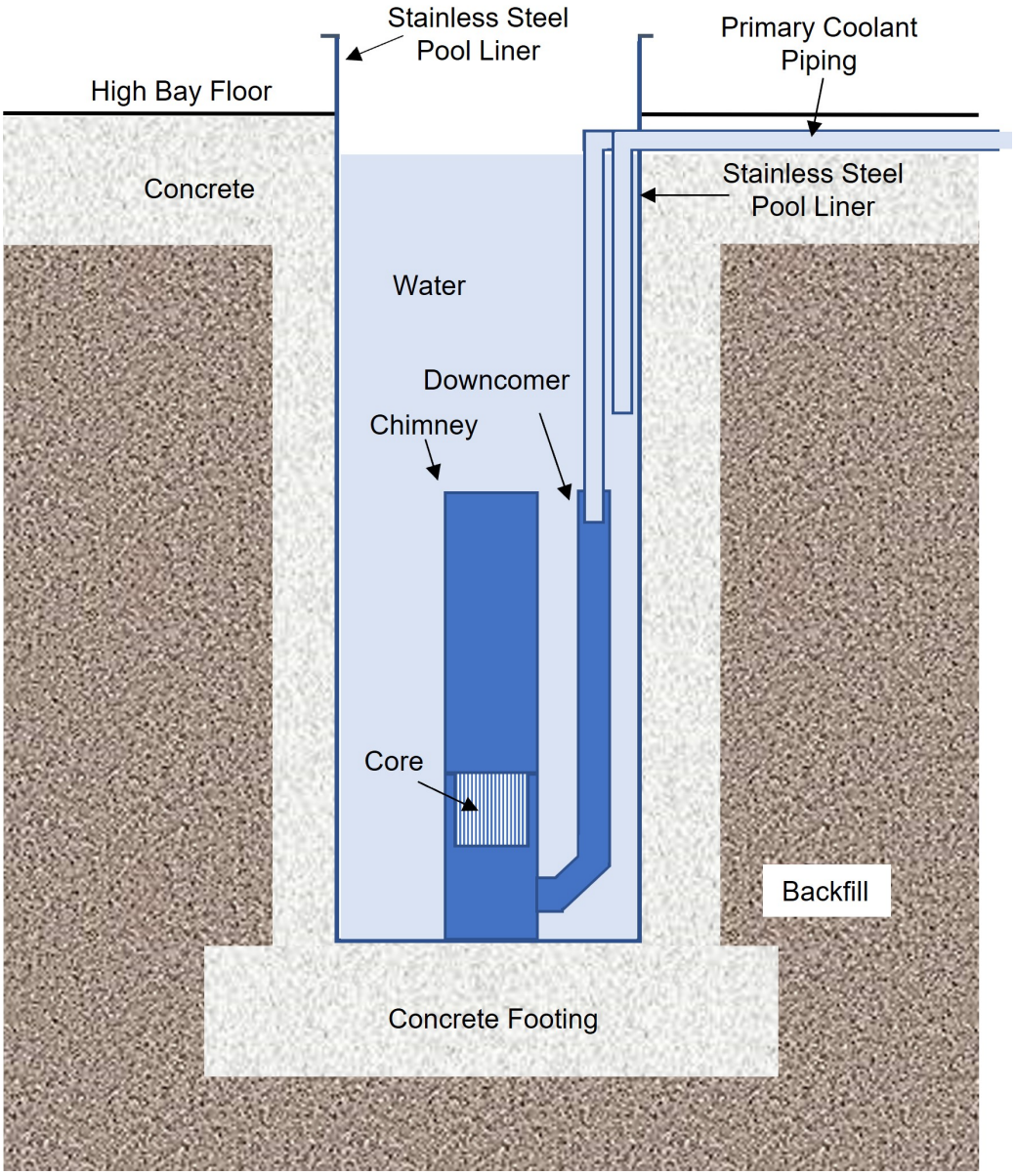


Figure 4a.3-2
Elevation of the Reactor Pool – Showing Dimensions and the Transfer Canal

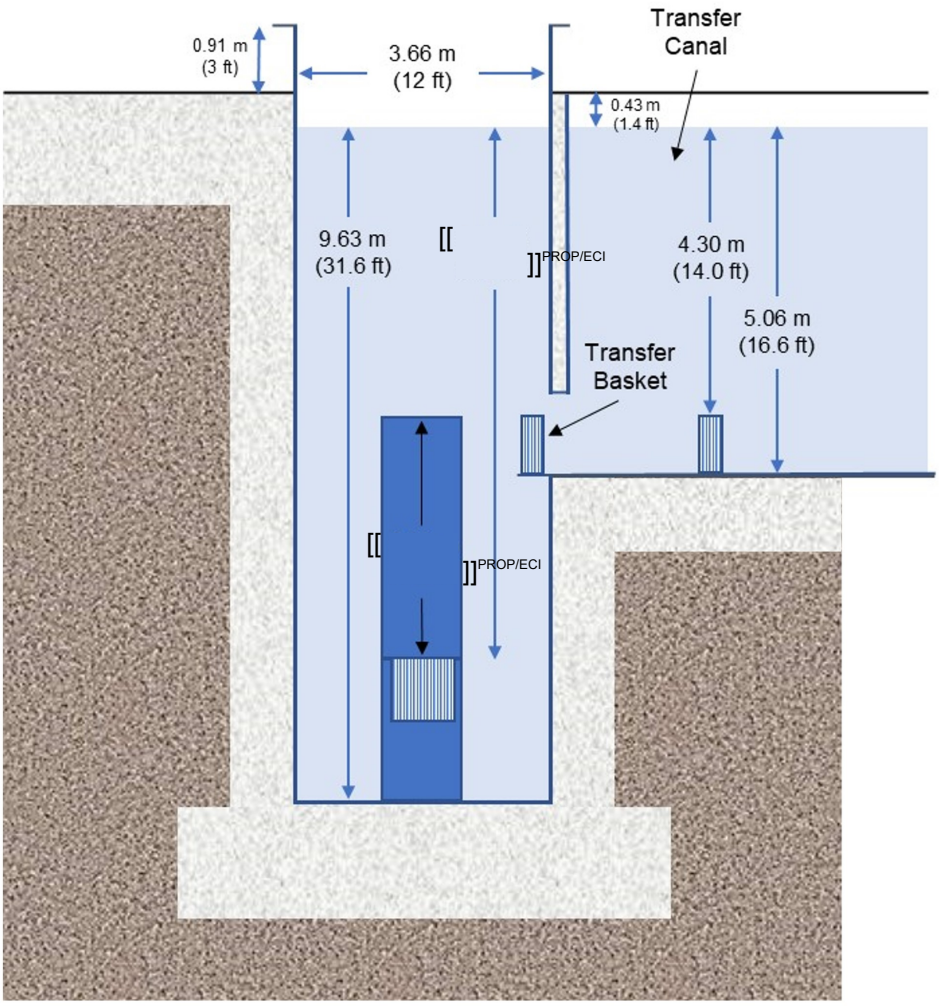


Figure 4a.5-1
Geometry for Targets in the Core Lattice

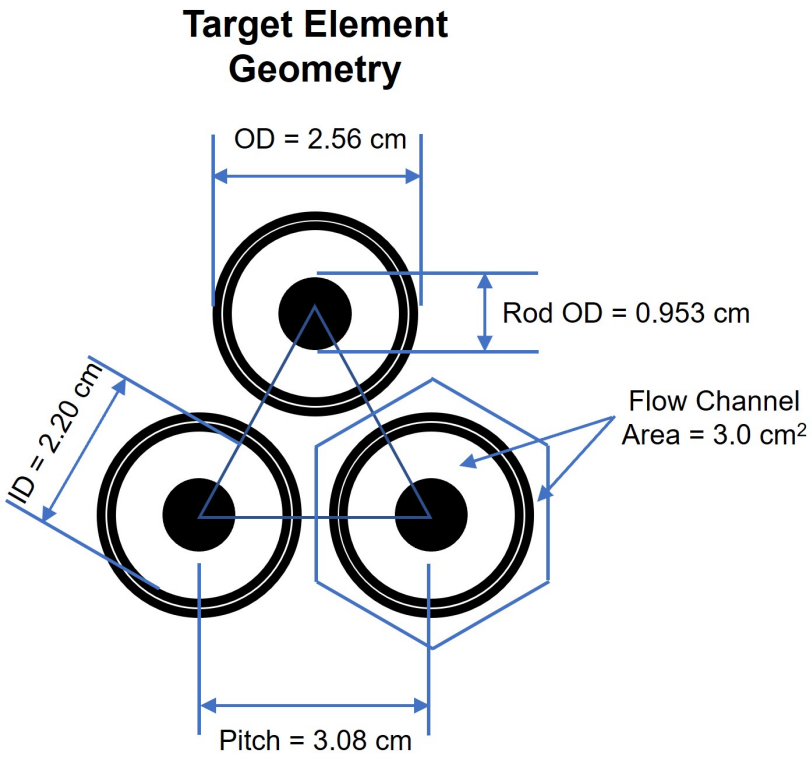


Figure 4a.5-2
Detailed View of the Core

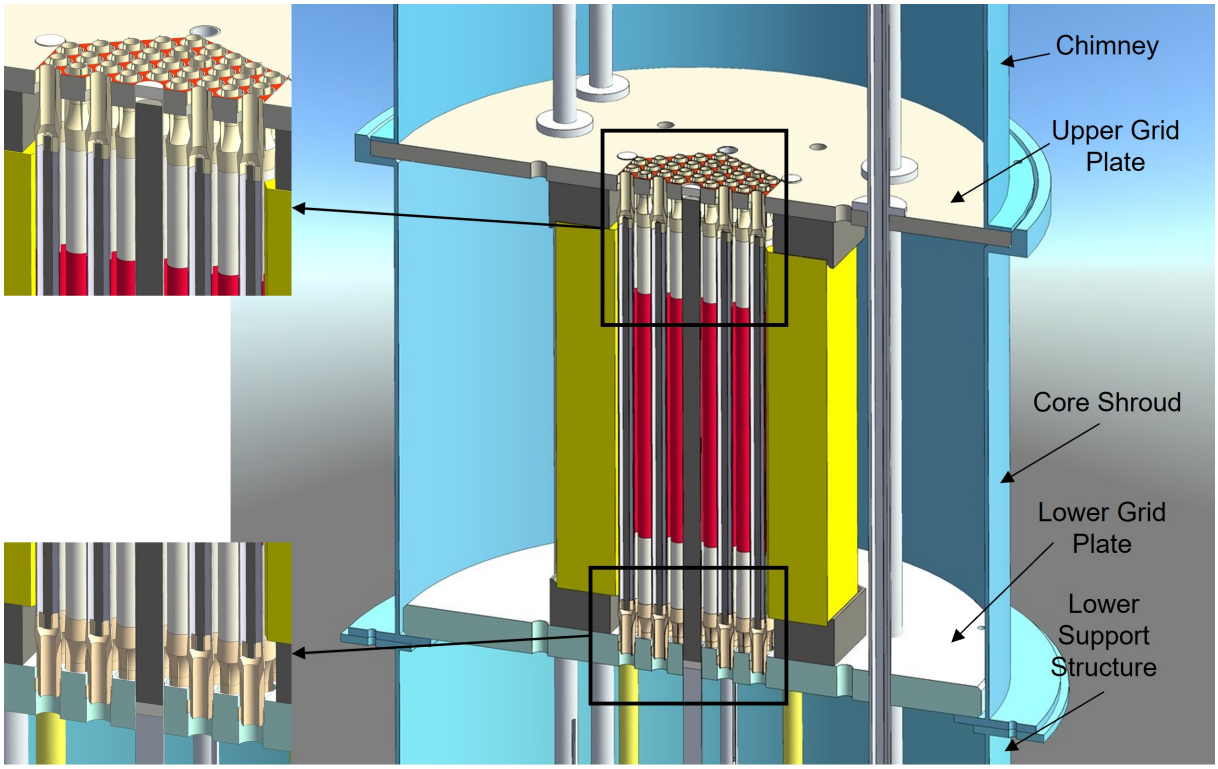


Figure 4a.5-3
MCNP Model of the Baseline All-Target Reactor Core

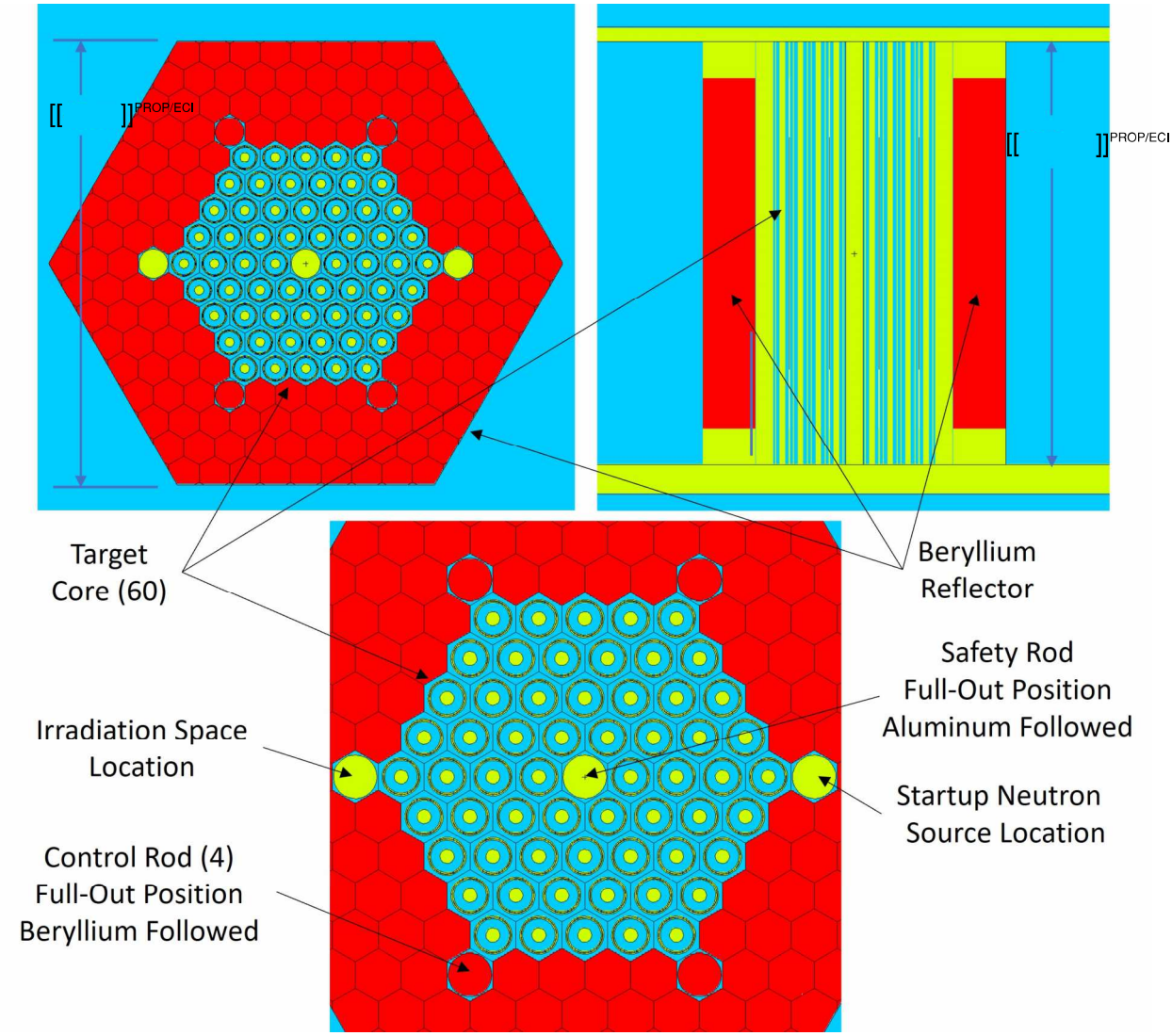


Figure 4a.5-4
MCNP Model with Control and Safety Rods Fully Inserted

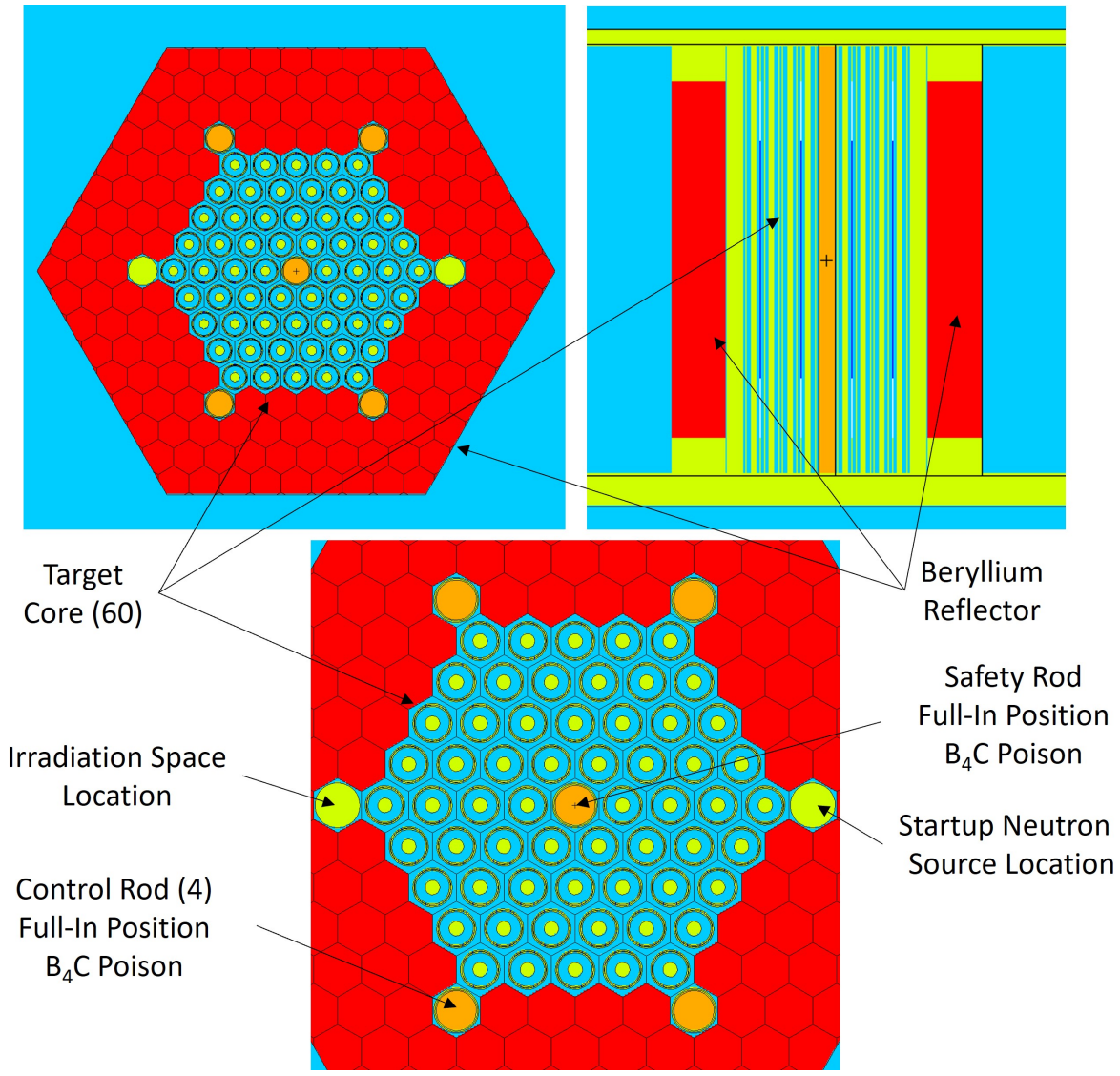
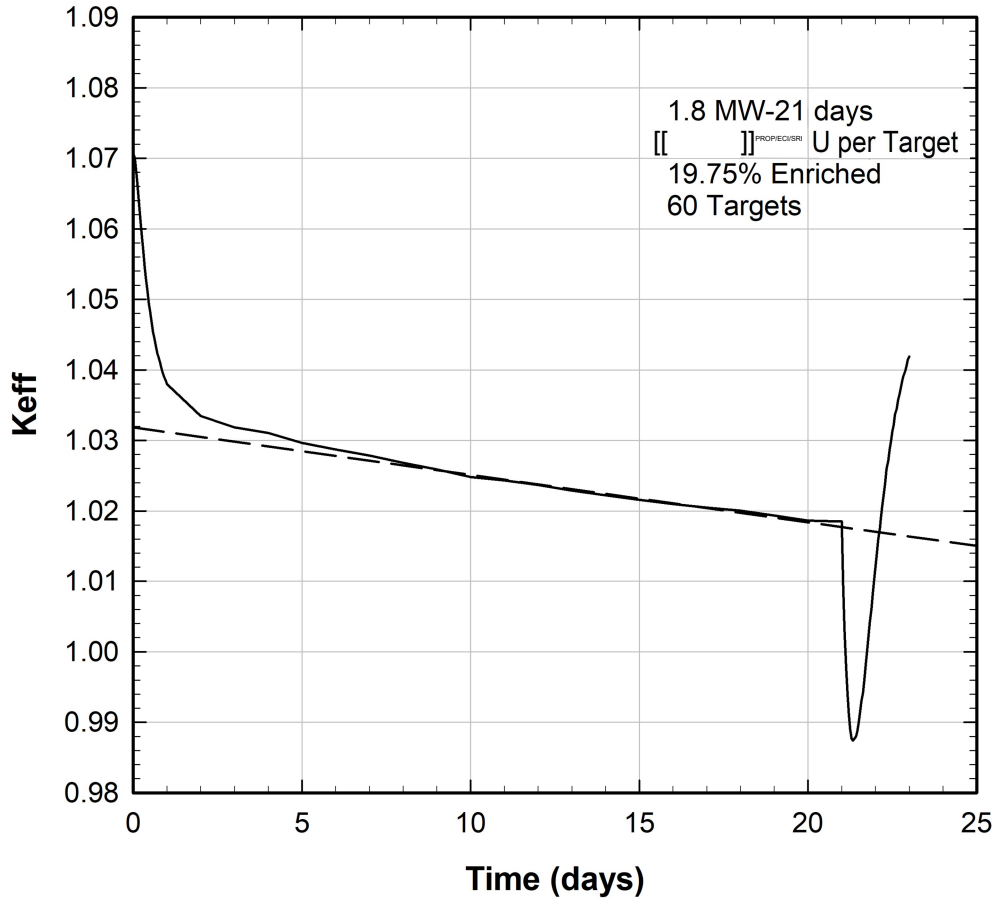


Figure 4a.5-5
MCNP K_{eff} Versus Burnup for the 60 Target – [[ ]]$^{PROP/ECI/SRI}$ U Target Loading Core



Notes:
The solid line represents the MCNP keff results as a function of burnup, starting with a clean-cold condition.
The dashed line is a linear representation of the reactivity effects as the U-235 is consumed.

Figure 4a.6-1
Target Temperature for an Average Target with an Axial Peaking Factor of 1.25 Using SOLIDWORKS

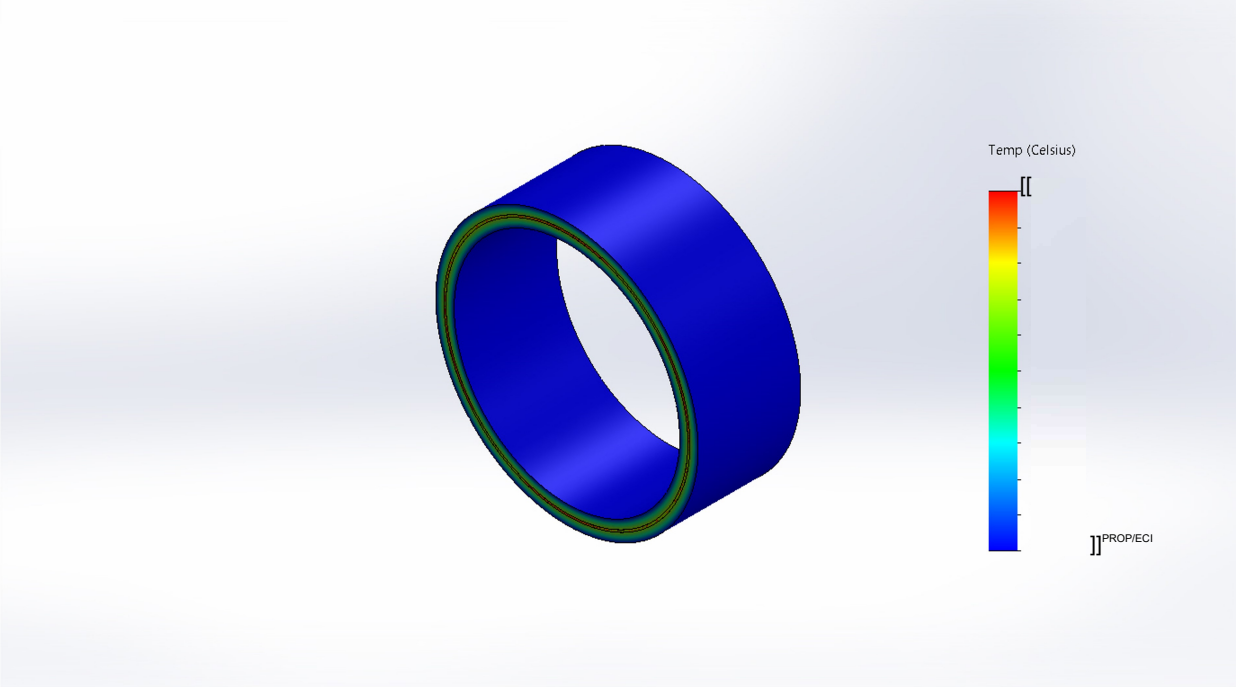


Figure 4a.6-2
Reflector Temperature for the Core Side Cooling Only Case Using SOLIDWORKS

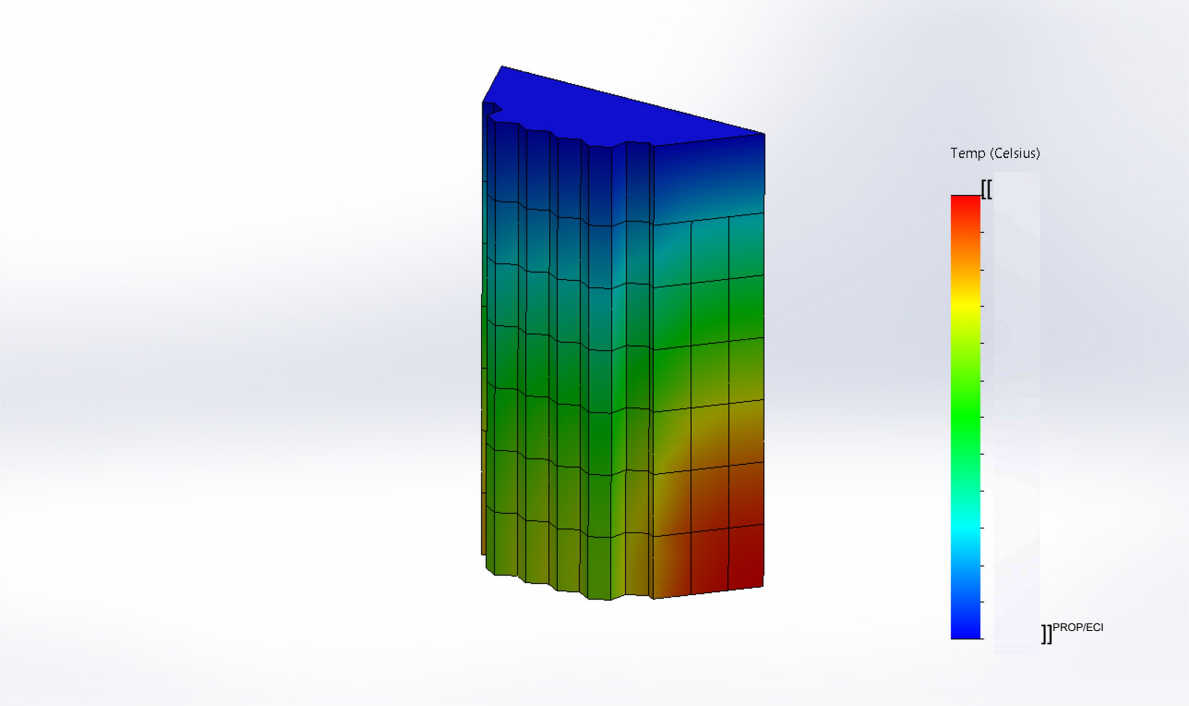


Figure 4a.6-3
Reflector Temperature for the Core Side Cooling and Back Side Cooling Case Using SOLIDWORKS

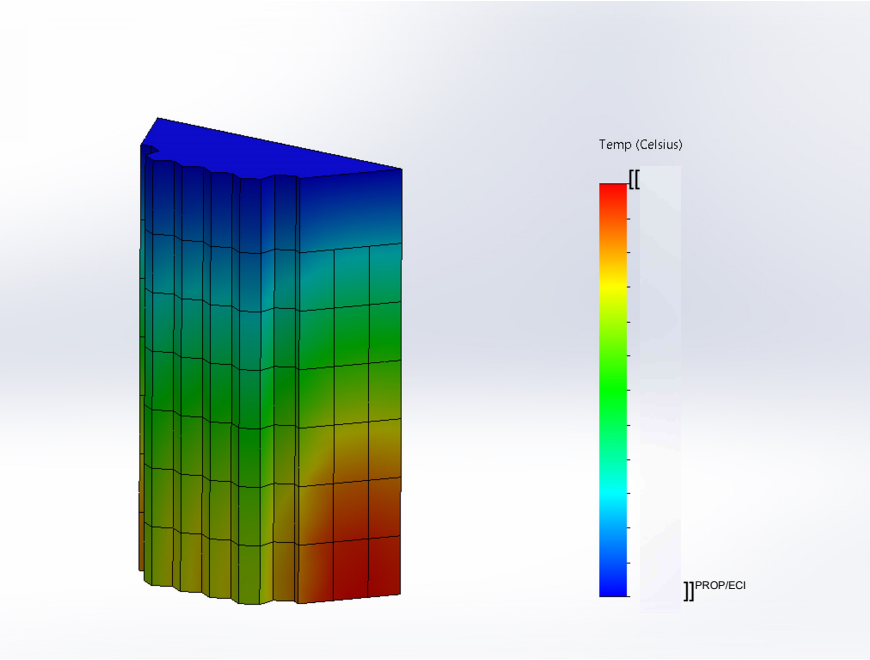


Figure 4a.6-4
Control Rod Poison Section (1-D) with Inner Container

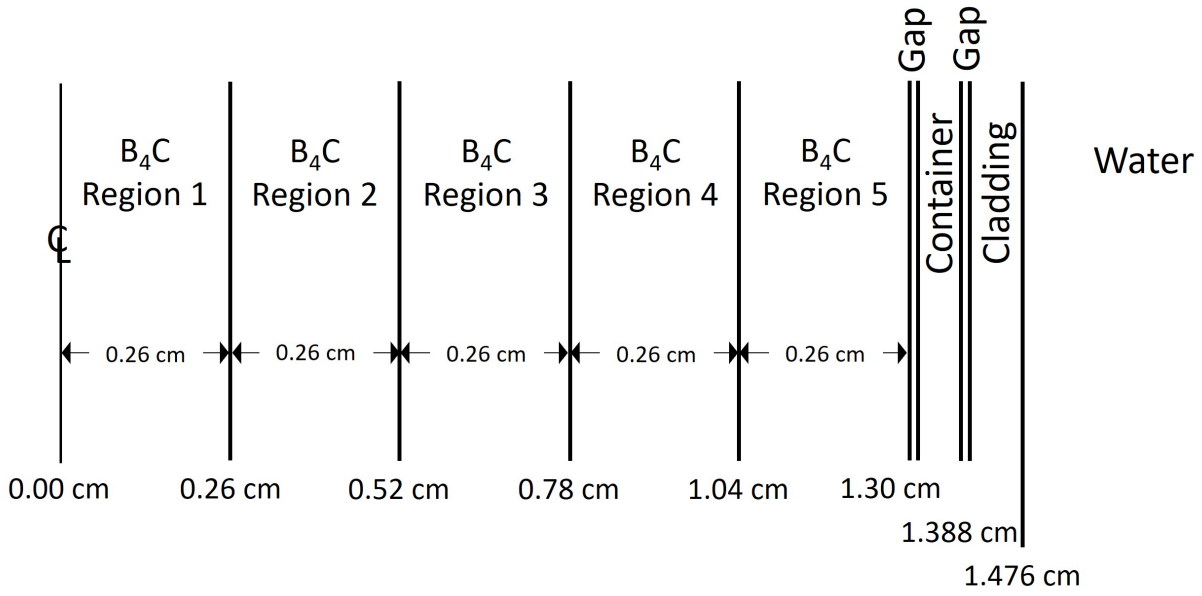


Figure 4a.6-5
Void Fraction Versus Quality for Pressurized Water Systems Under Non-Flowing Conditions

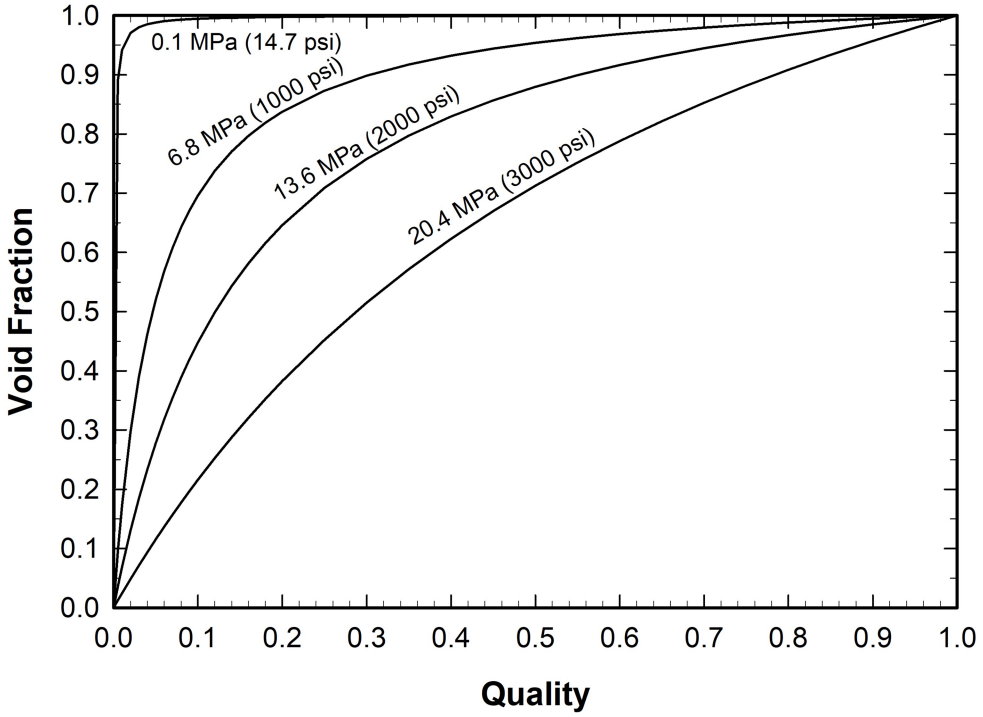


Figure 4a.6-6
Void Fraction Versus Quality for Flowing Conditions at Atmospheric Pressure

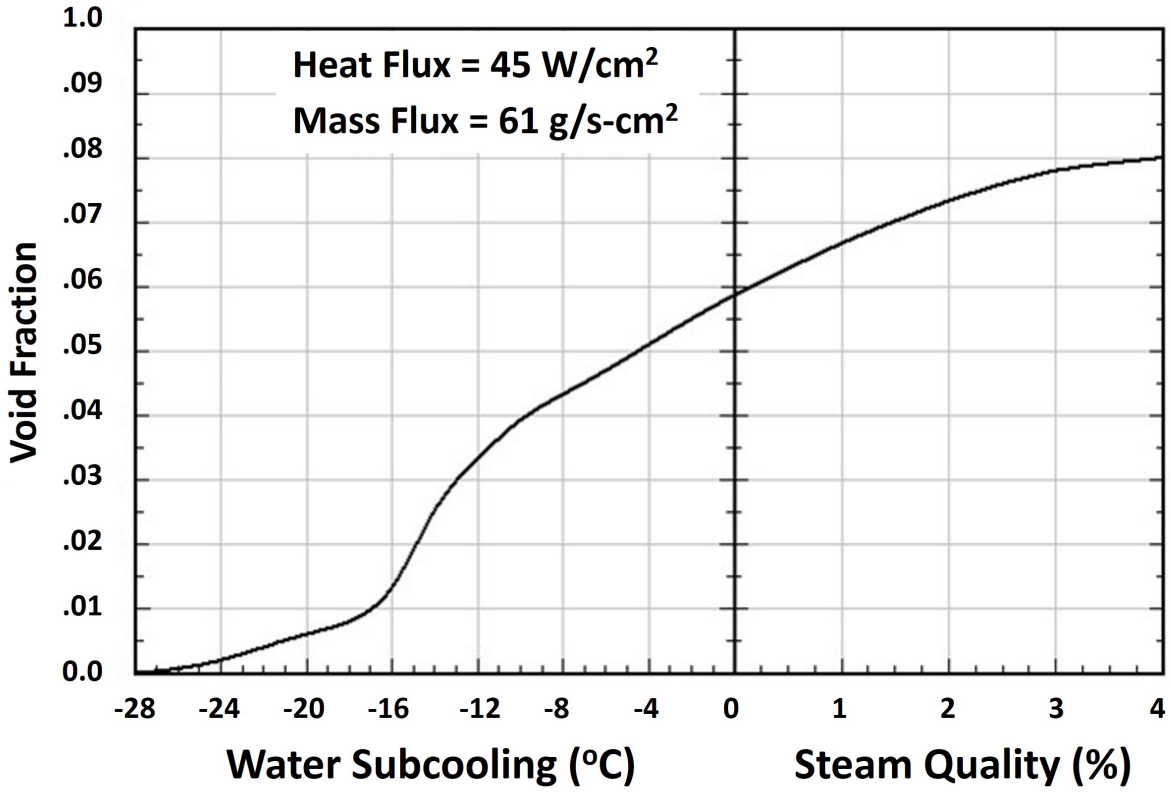


Figure 4a.6-7
Water Saturation Temperature as a Function of Pool Level

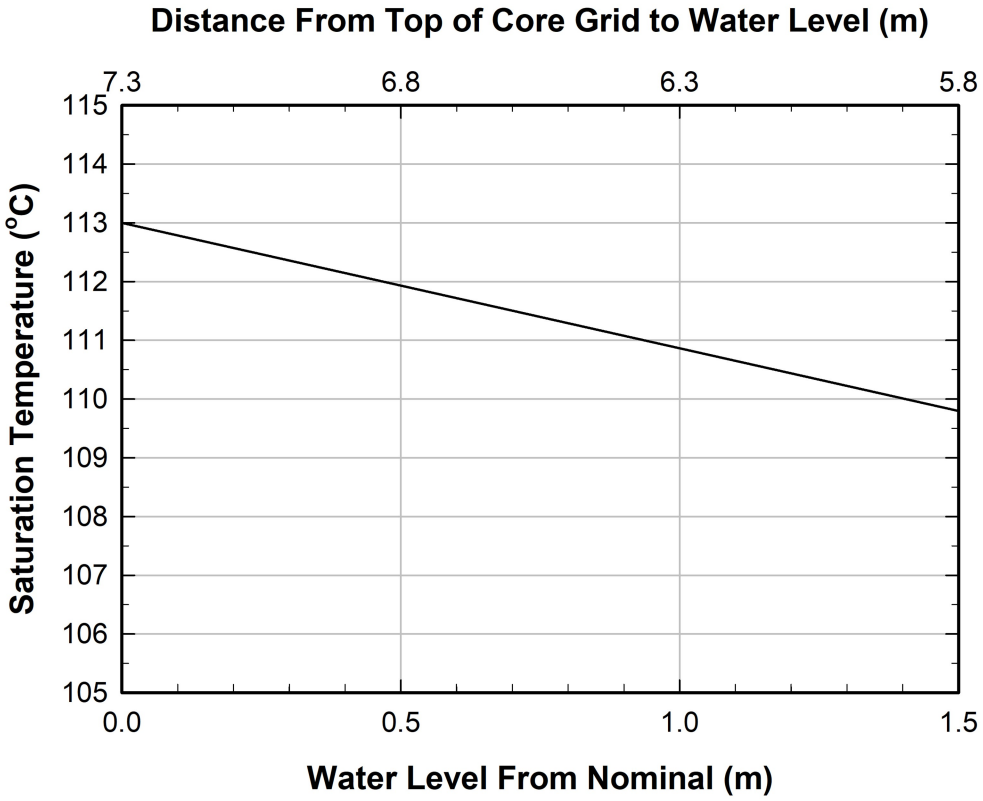


Figure 4a.6-8
Target Element Cladding Surface Temperature Axial Distribution as a Function of Target Power

[[

]]PROP/ECI

Figure 4a.6-9
Calculated Mass Flow Rate and Mass Flux for a Target Element Channel for a Target Power of a 30-kW and [[ ]]PROP/ECI Chimney as a Function of Inlet Temperature

[[

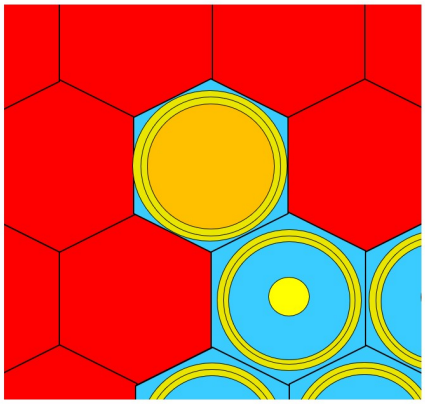
]]PROP/ECI

Figure 4a.6-10
Target Element Power Required to Reach Critical Heat Flux Conditions and Coolant Saturation Temperature as a Function of Inlet Coolant Temperature

[[

]]PROP/ECI

Figure 4a.6-11
Plan View of the Control Rod and Cooling Channel



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Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 4b
Radioisotope Production Facility Description

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CHAPTER 4b
RADIOISOTOPE PRODUCTION FACILITY DESCRIPTION

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4b.4-10	Axial Section of a Hydroformed Target

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
µm	micrometer
°C	degree Celsius
°F	degree Fahrenheit
ABO	Alpha-benzoin oxime
$AgNO_3$	silver nitrate
AIP	activation isotope processing
Al	aluminum
ANL	Argonne National Laboratory
Ca	calcium
CaO	calcium oxide
CFR	Code of Federal Regulations
cm	centimeter
cm^3	cubic centimeter(s)
DC	design criterion
DI	density inches
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Eden	Eden Radioisotopes, LLC
EMIF	Eden Medical Isotope Facility
Fe	iron
FGDS	fission gas delay system
ft.	feet
g	gram

Acronym/Abbreviation	Definition
gal.	gallon
H_2SO_4	sulfuric acid
HCF	Hot Cell Facility
HCl	hydrochloric acid
HDC	high-density concrete
He	helium
HEU	high-enriched uranium
HNO_3	nitric acid
H_2O	water
H_2O_2	hydrogen peroxide
hr.	hour
I-131	iodine-131
in.	inch
ISA	Integrated Safety Analysis
kg	kilogram
kJ	kilojoule(s)
$KMnO_4$	potassium permanganate
kW	kilowatt(s)
kWt	kilowatt thermal
L	liter
LANL	Los Alamos National Laboratory
lb.	pound(s)
LET	linear energy transfer
LEU	low-enriched uranium
LLW	low-level waste

Acronym/Abbreviation	Definition
m	meter
M	molar
MCP	modified Cintichem process
mils	thousandths of an inch
Mo-99	molybdenum-99
MPa	megapascal
mR	milli-Roentgen
MTS	material transfer system
MW	megawatt(s)
MWt	megawatt thermal
NaI	sodium iodide
NaOH	sodium hydroxide
Ni	nickel
NO	nitric oxide
NO_2	nitrogen dioxide
O_2	oxygen gas
oz.	ounce(s)
psi	pounds per square inch
QC	quality control
R&D	research and development
rad	radiation absorbed dose
RF	Reactor Facility
Rh	rhodium
Ru	ruthenium
s	second

Acronym/Abbreviation	Definition
SCB	steel confinement box
SNL	Sandia National Laboratories
SNM	special nuclear material
SSC	system(s), structure(s), and component(s)
TA-V	Technical Area V (at SNL)
TBP	tributyl phosphate
TS	Technical Specification(s)
U	uranium
U-235	uranium-235
UO_2	uranium dioxide
U_3O_8	uranium oxide
$UO_2(NO_3)_2$	uranyl nitrate
UPSS	uninterruptible power supply
UREX	uranium extraction
U.S.	United States
W	tungsten
Xe-133	xenon-133

4b. Radioisotope Production Facility Description

Chapter 4b provides a detailed description of the preliminary design and operation of the Eden Radioisotopes, LLC (Eden) production facility. The principal design features, operating characteristics, and parameters of the facility are described and discussed. The information presented in this chapter, along with the analysis in Chapter 13b, supports the conclusion that the facility is conservatively designed for safe operation and shutdown under all operating and credible accident conditions. The information provided in this chapter is used to provide the design bases for many of the systems, subsystems, and functions described elsewhere in this Preliminary Safety Analysis Report and the bases for the operating limits presented in the Technical Specifications (TS) in Chapter 14b. The information presented in this chapter represents the baseline configuration point design for isotope production. A more detailed description of the EMIF will be provided in the Operating License Application.

As described in Chapter 1, the Hot Cell Facility (HCF) portion of the Eden Medical Isotope Facility (EMIF) operates independently from the Reactor Facility (RF). The commonality between the facilities is the transfer canal, a wall separating the facilities, the liquid effluent control system, and common utilities. The HCF maintains its own ventilation system and exhaust stacks separate from the RF.

4b.1 FACILITY AND PROCESS DESCRIPTION

The EMIF is designed to produce diagnostic and therapeutic medical radioisotopes for the United States (U.S.) healthcare system. As described in Chapter 4a, the EMIF uses an all-target non-power reactor operating 24 hours per day, 7 days per week in the RF. The HCF processing facility operates with multiple shifts as required to meet the production demand. Both fission-produced radioisotopes (molybdenum-99 [Mo-99], iodine-131 [I-131], and xenon-133 [Xe-133]) and neutron activation produced radioisotopes (lutetium-177 and others) are produced in the RF and processed in the HCF.

There are several different areas of the HCF, including the target processing high bay that contains the target processing canyon, the target fabrication area, and the special nuclear material (SNM) storage area and the HCF basement that contains the waste storage canyon and the activation isotope processing (AIP) area. Also located in the HCF are a mechanical equipment room that contains ventilation equipment and the uninterruptible power supply system (UPSS), maintenance and storage areas, the quality control (QC) area, cask loading bay, and shipping areas.

Fission-produced isotopes are made by irradiating low-enriched uranium (LEU) targets in the reactor, as described in Chapter 4a, and subsequent processing of the irradiated targets in the HCF target processing canyon. The target processing canyon is a heavily shielded area of the HCF where all the product chemistry, product purification, and product waste preparation is performed. At full power, the LEU targets in the all-target reactor core operate at an average power level of 30 kilowatt thermal (kWt) up to a maximum burnup level of 0.75 megawatt (MW)-days. After irradiation, targets are transferred underwater in the transfer canal to the HCF target processing canyon for processing.

The fission radioisotopes are processed by acid dissolution of the irradiated uranium (U) metal foil material of the targets and chemical separation and purification of the radioisotopes of interest. The fission product waste is separated from the U using the uranium extraction (UREX) process. The U is converted into an oxide form and transferred from the target processing

canyon to the SNM storage area for later recycling back into targets. The waste is solidified in 55-gallon (gal.) (208-liter [L]) drums and stored for a decay period of 6 months to several years in the waste storage canyon. The waste drums are shipped to a low-level waste (LLW) disposal site as Class C waste in a Type-B shipping container.

Targets can be manufactured in the HCF target fabrication area or by an outside vender. If manufactured in the HCF target fabrication area, LEU oxide material that is fresh or recycled is converted into metal castings with the correct alloy composition. A casting is then rolled into foils of the correct mass and thickness, heat treated, and sheared to the correct dimensions. The LEU foils are coated with nickel (Ni), shaped into cylinders, and hydroformed with an inner and outer aluminum (Al)-6061 cladding.

To meet the U.S. demand for Mo-99, 30 targets are processed per week through the target processing canyon. At this production capacity, the facility uses 1500 targets per year.

4b.1.1 HOT CELL FACILITY ACTIVITIES

The principal activities in the HCF are:

- Irradiated LEU target processing.
- Waste storage.
- Waste shipping.
- Product shipping.
- SNM storage.
- Target fabrication.
- Activation isotope processing.

These activities have been evaluated and documented in a preliminary Integrated Safety Analysis (ISA) summary description (see Chapter 13b) to determine the hazards associated with each activity and to identify preventative and mitigative engineering and administrative controls. The final ISA will be provided in the Operating License Application.

4b.1.1.1 Irradiated LEU Target Processing

Irradiated target processing is performed in the HCF target processing canyon using the modified Cintichem process (MCP). A complete description of Mo-99 extraction using the MCP is found in Section 4b.3. Details of the biological shielding and the ventilation system are described in Section 4b.2.

The target processing canyon is shown in Figure 4b.1-1 and Figure 4b.1-2. The target processing canyon contains 19 steel confinement boxes (SCBs). All the activities for the MCP are performed within these SCBs. The SCBs are described in detail in Subsection 4b.1.2. The target process flow diagram is shown in Figure 4b.1-3. The SCBs are grouped by activity.

The activities in the target processing canyon SCBs are described below.

- Target receipt box – SCB 1:
  - Fresh target transfer into the target receipt box.

- Fresh target loading of the fresh target carrier.
- Fresh target carrier loading into the fresh target transfer basket.
- Fresh target transfer basket movement onto target transfer system within the transfer canal.
- Irradiated target carrier unloading from the irradiated target transfer basket.
- Irradiated target unloading from the irradiated target carrier.
- Irradiated target inspection, QC acceptance, and removal of hardware (target end fittings).
- Irradiated target grouping and transfer to designated dissolver box.

- Dissolver box – SCBs 2, 3, 4, 5:
  - Irradiated target disassembly and LEU metal foil removal
  - LEU metal foil placement in a dissolver unit
  - Dissolver unit vessel sealing
  - Dissolver unit vessel evacuation and monitoring for leaks
  - Addition of nitric acid (HNO_3) and [[ ]]$^{PROP/ECI}$ into the dissolver unit vessel
  - Dissolution of LEU metal foil
  - Evacuation of noble gases and iodine from the dissolver unit vessel using the fission gas delay system (FGDS)
  - Mo-99 capture on the titania column
  - Uranyl nitrate ($UO_2(NO_3)_2$) solution capture into the transfer container
  - Container transfer to UREX process box
  - Titania column rinse to produce Mo-99 solution
  - Mo-99 solution transfer to a purification box
  - Waste material transfer to the waste packaging box
- Purification box – SCBs 13, 15, 17, 19:
  - Modified Cintichem process operations of the Mo-99 solution
  - QC sample preparation
  - Final Mo-99 solution packaging
  - Transfer of final Mo-99 solution to packaging box
  - Waste material transfer to the waste packaging box
- Packaging box – SCBs 12, 14, 16, 18:
  - Movement of the product shield into the packaging box
  - Loading product into the shield
  - Contamination surveys
  - Process chemical kit transfer

  - Product quality sample transfer
- UREX process box – SCBs 8, 10, 11:
  - Movement of $UO_2(NO_3)_2$ and fission product solution transfer container into the UREX process box
  - Performance of the UREX process using tributyl phosphate (TBP) and dodecane
  - Collection of the raffinate solution and transfer to the waste packaging box for solidification
  - Processing the $UO_2(NO_3)_2$ for recycling
  - Removal of the LEU oxide from the UREX process box
- Waste packaging box – SCB 9:
  - Receipt of all waste products from the target processing canyon to the waste packaging box.
  - Staging 55-gal. (208-L) drums for acceptance of the waste.
  - Mixing of the liquid waste with grout in the drum.
  - Addition of the solid waste materials.
  - Addition of sand to fill voids in the drum.
  - Placement of lid with vent on the drum and seal.
  - Staging drum for transfer to the waste storage canyon.
- Research and development (R&D) box – SCBs 6, 7:
  - Processing of other fission product isotopes.

4b.1.1.2 Waste Storage

The waste storage canyon, located in the basement of the HCF, is directly below the target processing canyon within heavily shielded walls, as described in Section 4b.2. The waste drums are lowered into the waste storage canyon on carts using an elevator system and are staged on a track for decay. The waste drum carts are moved along the length of the waste storage canyon to the cask loading bay.

Activities performed as part of the waste storage activity include the following:

- Staging of waste drums on a cart for transfer to the waste storage canyon.
- Lowering the cart into the waste storage canyon.
- Moving carts along conveyance system.
- Staging carts for waste shipping.

4b.1.1.3 Waste Shipping

The waste drums are removed from the waste storage canyon using a transfer system that is located in the cask loading bays, allowing waste drum transfer operations to be conducted without interference with isotope production. The waste drums are loaded into a U.S. Department of Transportation (DOT) Type B shipping container using remote operations in the

cask loading bay with strict personnel access controls as required by the Radiation Protection Program.

Activities performed as part of the waste shipping activity include the following:

- Staging and preparing waste drums for transfer.
- Preparation of the Type B shipping container for waste drum loading.
- Transfer of waste drums to Type B shipping container.
- Sealing and assembly of the Type B shipping container for shipment.
- Completion of QC inspections, shipping manifest, and placarding requirements.
- Release of the Type B shipping container for over the road shipment.

4b.1.1.4 Product Shipping

After removal of the shielded product from the packaging box, the container with product is placed within the DOT overpack to meet regulatory requirements for shipment, placarded, and shipped.

Activities performed as part of the product shipping activity include the following:

- Preparation of the Type B shipping container.
- Insertion of shielded product container.
- Sealing and assembly of the Type B shipping container.
- Completion of QC inspections, shipping manifest, and placarding requirements.
- Release of the Type B shipping container for product shipment.

4b.1.1.5 SNM Storage

Secure SNM storage is managed within the HCF. SNM storage is used to sequence the steps in target fabrication and to maintain an inventory of LEU and targets ready for irradiation in the RF. The SNM storage area contains partitions and racks that allow for criticality safe geometries.

Activities performed as part of the SNM storage activity include the following:

- Storage of LEU metal or oxide from supplier.
- Storage of reclaimed LEU oxide.
- Storage of LEU metal ingots.
- Storage of LEU metal foils.
- Storage of assembled LEU targets.

4b.1.1.6 Target Fabrication

Fresh targets are manufactured in the HCF target fabrication area. LEU oxide material that is fresh or reclaimed is converted into metal castings with the correct alloy composition. A casting

is then rolled into foils of the correct mass and size, heat treated, and sheared to the correct dimensions. The LEU foils are coated with Ni, shaped into cylinders, and hydroformed with an inner and outer Al-6061 cladding.

4b.1.1.6.1 SNM Blending

SNM blending is performed in the target fabrication area. SNM is lost through processing and LEU enrichment is reduced through burnup. An SNM source provides 19.75 percent enriched U to make up for these two losses. Blending may occur with LEU metal or LEU oxide powder. Blending operations are performed in a ventilation hood.

4b.1.1.6.2 Oxide to Metal Reduction

Oxide to metal reduction is performed in the target fabrication area. A glovebox or ventilation hood is used to accomplish the [[

]]PROP/ECI.

4b.1.1.6.3 Ingot to Foil Production

LEU metal ingot to metal foil production is performed in the target fabrication area. A rolling mill, salt bath, furnace, and shears are used to form the LEU metal ingots into metal foils. The foils are then heat treated, shaped, and Ni coated in preparation for target fabrication.

4b.1.1.6.4 Foil to Target Production

Target production is performed in the target fabrication area. LEU metal foils are clad with Al tubing using a hydroforming process.

4b.1.1.7 Activation Isotope Processing

Activation isotope targets are irradiated in the reactor over several days or weeks and then transferred to the target receipt box using the target transfer system in the transfer canal. The irradiated activation targets are moved in a shielded container from the target receipt box to a shielded processing box in the basement of the HCF. The activation material is separated from the target, processed to separate the product material from the parent material, purified, packaged, and shipped to the customer. The parent material is prepared for reuse.

Depending on the number of activation products irradiated, several shielded processing box stations are within the HCF basement for dedicated use to minimize possible cross contamination of the product material.

4b.1.2 HOT CELL FACILITY DESCRIPTION

There are several functional areas of the HCF for performance of the activities described above:

- HCF target processing high bay:
  - Target processing canyon.
- Target fabrication area.
- SNM storage area.

- HCF basement:
  - Waste storage canyon.
  - AIP area.
- Cask loading bay.
- Other spaces include a mechanical equipment room that contains ventilation equipment and the UPSS, maintenance and storage areas, the QC area, and shipping areas.

The EMIF layout, which includes the HCF, is shown in Figure 4b.1-4a and 4b.1-4b. The HCF contains a first floor, basement, and a mezzanine. The first floor is at ground level and is at the same elevation as the RF. The HCF first floor shares a common wall with the RF and the transfer canal. The purpose of the wall is to maintain separation between the facilities such that the operations in one facility do not impact those in the other and to control the ventilation in each facility through independent exhaust stacks. This unique feature allows for the two facilities to be operated independently, while at the same time maintaining irradiated target transfer efficiency.

The HCF first floor contains the target processing high bay, target fabrication area, SNM storage area, cask loading bay, and other spaces, including maintenance and storage areas and locker rooms. The HCF basement contains the waste storage canyon, AIP area, and other spaces, including the mechanical equipment room, storage areas, and the QC product area.

The following design criteria (DC) apply to the HCF design:

- DC 10, Confinement: The HCF Zone 1a ventilation system and associated dissolver boxes that establish the confinement boundary are safety-related and are designed to establish a low-leakage barrier against uncontrolled releases of radioactivity to the rest of the facility and the environment and to ensure that the released effluent is filtered and discharged through the HCF Zone 1a exhaust stack. The ventilation system is further described in Chapters 6b and 9b.

  The HCF Zone 1b, 1c, 1d, 2, and 3 ventilation system and associated components that establish confinement boundaries are nonsafety-related and designated for defense in depth. They are designed to establish a low-leakage barrier against uncontrolled releases of radioactivity to the rest of the facility and the environment and to ensure that the released effluent is filtered and discharged through the HCF exhaust stack. These are further described in Chapter 9b.
- DC 17, Chemical Protection: Design of the HCF provides adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The HCF ventilation system design provides the means to control the environmental release of radioactive materials in gaseous and volatile forms through the filtered exhaust stacks during normal operation, anticipated operational occurrences, and accident conditions. The safety-related portion of the system is described in Chapters 6b. The nonsafety-related portion of the system is described in Chapter 9b.

  Radioactive liquid wastes are solidified and placed with radioactive solid waste in drums and stored in the waste storage canyon for decay and eventual disposal at an LLW

disposal site. The waste is controlled in accordance with the Radioactive Waste Management Program as described in Chapter 11.

- DC 19, Radioactive Material Control: Production and support systems that store, handle, or process radioactive materials or radioactive waste are designed in accordance with the Eden Quality Assurance Program to ensure safety under normal operation, anticipated operational occurrences, and accident conditions. Appropriate systems are provided to detect conditions that may result in excessive radiation levels and to initiate appropriate safety actions. System design includes the capability to perform periodic inspection and testing.
- DC 20, Criticality Control: Criticality in the SNM storage area, target processing canyon, and in the target fabrication area is prevented by physical systems, processes, and the use of geometrically safe configurations. The Nuclear Criticality Safety Program is described in Chapter 6b. A criticality accident alarm system is provided as described in Chapter 7b. DC 22, Inspection, Testing, and Maintenance: The design of the HCF biological shield, including the target processing canyon and the waste storage canyon, are safety-related systems, structures, and components (SSCs). These shields are made of reinforced concrete and steel, which are passive design features. Included within are active shield systems for material transfer into and out of the target processing canyon. These active systems include adequate inspection, testing, and maintenance capabilities to ensure their availability to reliably perform their function when needed.

  The dissolver SCBs and associated HCF Zone 1a ventilation system, UPSS, and equipment room are safety-related SSCs. These systems include adequate inspection, testing, and maintenance capabilities to ensure their availability to reliably perform their function when needed. These are further described in Chapters 6b, 8 and 9b.

- DC 23, Biological Shielding: The HCF biological shield, including the target processing canyon and the waste storage canyon, is safety-related. The shielding is a passive design feature made of reinforced concrete and steel. The shielding is designed to provide worker protection between the target processing canyon and personnel work areas, as well as between the waste storage canyon and personnel work areas, from radiation that may be generated from normal operations, anticipated operational occurrences, and accident conditions. Structures surrounding or adjacent to the biological shielding structural features are nonsafety-related.

4b.1.2.1 Target Processing High Bay

The HCF target processing high bay contains the target processing canyon and accompanying support facilities for the safe processing of the irradiated LEU targets. The target processing high bay is accessible by HCF staff on the first floor of the EMIF. The ventilation for the high bay (HCF Zone 3) is supplied through a once-through air system and discharged through the HCF exhaust stack as described in Chapter 9b.

The target processing canyon is heavily shielded using steel plate and high-density magnetite concrete (HDC) for worker radiation protection during target processing. As described above, there are 19 SCBs within the canyon, each with their own unique processing activity function. The target processing canyon has inside dimensions approximately [[ ]]$^{PROP/ECI}$. The biological shielding design is described in Section 4b.2. The HCF target processing canyon volume and SCBs are operated at a negative pressure as described in Chapters 6b and 9b.

The main purpose of the SCB is to maintain contamination control during processing activities for both normal operations and abnormal conditions. Identified as a confinement barrier, the SCB maintains negative differential pressure such that air flow is always maintained from a potentially lower contamination area to a potentially higher contamination area. An SCB is a welded stainless-steel box that has ventilation connections, pass through connections for manipulators, and transfer ports for material and hardware movement. Lead glass and oil filled shield windows allow for lighting and viewing within the box. Ventilation connections on each SCB allow for air to flow from the volume in the target processing canyon into the SCB, and from the SCB to the ventilation systems filters, and then to the environment via the HCF exhaust stacks. As described in Chapters 6b and 9b, the Zone 1a ventilation system exhausts to a separate stack than the other HCF zone ventilation systems.

The four dissolver box SCBs, four purification box SCBs, and four packaging box SCBs allow for both adequate processing capabilities and redundancy in operation. The U.S. demand for Mo-99 requires 30 targets to be processed per week. Each of the four dissolver boxes has one shield window and one pair of manipulators. A dissolver box has two dissolver unit stations for redundancy. Each dissolver unit station can process up to six targets as a batch. Only one dissolver unit is used at one time within a dissolver box, but all four of the dissolver boxes can be operated at one time, allowing for the dissolution of up to 24 targets in one day.

Once the dissolution activities are completed and the Mo-99 is separated from the LEU and fission product solution via the titania column, the Mo-99 solution is transferred to a purification box for product purification and QC. The Mo-99 solutions may be combined or separated prior to purification depending on the customer requirements.

The target receipt box acts as the internal canyon entry system for fresh targets and irradiated targets. The target receipt box is not used for processes that could generate spreadable contamination as a defense in depth measure to avoid contamination of the transfer canal water.

The other SCBs include the R&D boxes, the UREX boxes, and the waste packaging box.

Some of the SCBs include shielded passthroughs and drawers that allow process supplies to be introduced into the target processing canyon, as well as shielded products to be transferred from the packaging boxes for quality inspection and shipment. Products transferred from the SCBs include sellable radioisotopes byproduct material, as well as recovered U from the UREX process.

Lead glass and oil-filled shield windows provide direct observation of the process steps for each SCB activity. Telemanipulators allow operators to perform work remotely in the SCBs. Lighting for the SCBs is through pedestal mounted fixtures located above each SCB and serviceable from the worker area. Process fluids (liquid and gases) and electrical power are introduced into the SCBs through serpentine shielded feedthroughs engineered into the shield window liners.

An SCB material transfer system (MTS) operates between the target receipt box and the waste packaging box, as shown in Figure 4b.1-5. The purpose of the MTS is to move targets, process consumables, hardware, and product from SCB to SCB. The system uses three types of baskets to move targets, containers, and other hardware. The drive mechanism is located within the MTS and incorporates a magnetically coupled drive unit. The drive motor is located outside of the target processing canyon.

4b.1.2.2 Target Fabrication Area

The target fabrication area is a separate area located on the first floor of the HCF, as shown in Figure 4b.1-4a, is accessed by HCF staff through hallways directly leading from the EMIF entrance and from the target processing high bay. The target fabrication area ventilation system (HCF Zone 3) is the same as for the target processing high bay, as described in Chapter 9b. The target fabrication area maintains all the equipment required to perform the LEU target fabrication for the reactor. Subsection 4b.4.2 describes the process equipment and details for target fabrication.

4b.1.2.3 SNM Storage Area

The SNM storage area is a separate area located with the HCF. [[ ]]^{SRI}. All the fresh and recycled LEU material is stored within the SNM storage area in criticality safe arrays and containers as described in Chapter 6b. The SNM storage area ventilation system (HCF Zone 3) is the same as for the target processing high bay, as described in Chapter 9b.

4b.1.2.4 HCF Basement

The HCF basement contains the waste storage canyon, AIP area, and other spaces including the ventilation system mechanical equipment room, storage areas, and the QC product area. The basement is accessible by HCF staff through a stairwell and freight elevator. The ventilation system for the basement general area (HCF Zone 3) is the same as for the target processing high bay, as described in Chapter 9b.

4b.1.2.4.1 Waste Storage Canyon

The HCF waste storage canyon is heavily shielded using steel plate and concrete for worker radiation protection during waste storage and decay. As shown in Figure 4b.1-6, the waste storage canyon is located directly below the target processing canyon. The canyon uses a dual track system to remotely move waste drums stacked in groups of eight (4 + 4) on carts with track-captured wheels. The waste storage canyon has inside dimensions of approximately [[ ]]$^{PROP/ECI}$. The shielding design is described in Section 4b.2. The canyon volume is operated at a negative pressure in ventilation HCF Zone 2, as described in Chapter 9b.

Two canyon elevators move a four drum cart from the HCF target processing canyon to the HCF waste storage canyon. Two interlocked shield doors are used to allow for clean/empty waste drums and carts to enter the HCF target processing canyon.

The main purpose of the waste storage canyon is to allow for the highly radioactive grouted fission product waste within a 55-gal. (208-L) waste drum to be staged for decay prior to shipment to a LLW disposal site as Class C waste. The dual track allows for redundancy and capacity for up to 400 drums to be stored for decay. Manipulator and shielded window stations are staged along the length of the canyon to allow the drum carts to be remotely moved along the track until they reach the end of the canyon. The lead glass and oil-filled shield windows allow for viewing within the canyon.

Once the drum carts reach the end of the canyon, and sufficient decay time has elapsed, the drum carts are remotely moved to either of the two cask loading bays (A/B) for shipment. The

waste is controlled in accordance with the Radioactive Waste Management Program as described in Chapter 11.

4b.1.2.4.2 Cask Loading Bay (A/B)

The cask loading bays (A/B) allow for redundancy in shipping the waste drums to the LLW disposal site. After a drum cart reaches the end of the waste storage canyon and the waste drums are ready to be shipped, the drum cart is remotely directed to the assigned cask loading bay for drum preparation and shipment. Preparation for shipment includes removing the drum from the cart through a transfer shaft and hatch using a remote operated crane, as further described in Chapter 9b. The drum is surveyed for contamination and placed into the shipping cask. The shipping cask is loaded with drums and prepared for shipment. The number of drums shipped is dependent on the Type B shipping container and the acceptance criteria for the LLW disposal site.

4b.1.2.4.3 Activation Isotope Processing Area

AIP stations are located in the HCF basement. It is expected that several stations are operated to prepare different activation isotopes for the customer. Each station is a free-standing shielded box or series of interconnected boxes that are ventilated to the HCF ventilation system described in Chapter 9b. Because activation isotopes are radioactive but emit less intense radiation (gamma rays) compared to fission products, the shielded boxes require much less biological shielding compared to the target processing canyon. [[

]]$^{PROP/ECI}$. Activation target processing includes a radiochemistry process to separate the desired medical radioisotope from the parent material. The parent material is then recycled into a fresh activation target for reuse.

4b.1.2.4.4 Other Basement Areas

Other spaces within the HCF basement include mechanical equipment rooms that contains ventilation equipment, maintenance and storage areas, and the QC area.

The safety-related HCF Zone 1a mechanical equipment room maintains all of the headers, manifolds, filter banks, and fans and UPSS required to maintain the ventilation exhaust to the HCF Zone 1a exhaust stack. The details of the HCF Zone 1a ventilation systems are described in Chapter 6b.

The QC area contains the radiation metrology laboratory, including fume hoods and highly sensitive radiation detection equipment to ensure that the product quality is maintained for the Mo-99 and other product radioisotopes prior to shipping the products off-site.

4b.2 PROCESSING FACILITY BIOLOGICAL SHIELD

The HCF target processing canyon and the HCF waste storage canyon are safety-related structures in the EMIF as described in Chapter 3. The biological shields, including the shield windows, provide the necessary radiation shielding to maintain the worker dose rates to less than 0.005 millisievert per hour (0.5 millirem/hr) averaged over the year during normal operational hours.

4b.2.1 SHIELDING CALCULATIONS

Shielding calculations were performed for both the HCF target processing canyon and waste storage canyon. MicroShield, Version 7.02, was used to perform the calculations using a gamma-ray energy spectrum from ORIGEN2, Version 2.2. Conditions were analyzed with different amounts of shielding to determine the design requirements for the target processing canyon and waste storage canyon. Analyses were performed for an average target irradiated for 25 days at 30 kilowatts (kW) with a 6-hr. decay, 6-month decay, 1-year decay, and 2-year decay.

The results of the MicroShield analysis are in units of radiation exposure in air, milli-Roentgen per hour (mR/hr). This corresponds to the values measured by a nuclear radiation monitoring instrument. For an exposure of 1 Roentgen by gamma rays with an energy of 1 million electron volts, the dose in air would be 0.877 rad (radiation absorbed dose), the dose in water would be 0.975 rad, and the dose in tissue would be 1 rad.

Figure 4b.2-1 shows a cutaway view of the target processing canyon at one of the dissolver box stations and Figure 4b.2-2 shows a schematic of the MicroShield model. The source is a point source with an inventory of one to six targets of fission products. This case represents the operations in the dissolver box during target handling and dissolution of up to six targets. The model includes [[ ]]$^{PROP/ECI}$ of air to the dose point. The stainless-steel is modeled in MicroShield as iron (Fe), 7.86 grams per cubic centimeter (g/cm^3). The [[ ]]$^{PROP/ECI}$. The total amount of shielding material is [[ ]]$^{PROP/ECI}$.

Table 4b.2-1 presents the MicroShield results for the fission product inventory with a 6-hr. decay period. The results for no shielding are also presented. A target decayed 6 hr. has an exposure rate of [[ ]]$^{PROP/ECI}$ from the source with no shielding. A shield design with [[ ]]$^{PROP/ECI}$ is sufficient to allow for an exposure rate of 1 to 5 mR/hr during the target processing activities. [[ ]]$^{PROP/ECI}$ of stainless-steel reduces the exposure rate by more than seven orders of magnitude, allowing for the worker to safely perform the target processing activities.

The same basic shielding geometry is used for the analysis and design of the waste storage canyon shielding. [[ ]]$^{PROP/ECI}$, depending on the final shielding requirements. Figure 4b.2-3 shows a MicroShield model of a waste drum filled uniformly with fission products and nominal density concrete and a nominal density concrete side shield [[ ]]$^{PROP/ECI}$. The model assumes 15 targets of fission products and decay times of 6 months, 1 year, and 2 year.

The MicroShield results are presented in Table 4b.2-2. For one drum next to a shield wall, the dose rates are 0.002 mR/hr or less with 6 months of decay or more.

After the desired decay period, the waste drums are shipped in a Type B shipping container to a LLW disposal site. The drums are remotely removed from the drum cart in the cask loading bay and loaded in the shipping container. It is expected that 10 waste drums are shipped in a shipping container at one time. If the facility is fulfilling the full U.S. product demand, 30 targets are processed per week and a shipment is made every 5 weeks.

Table 4b.2-3 presents MicroShield results for a waste drum with 15 targets of fission product inventory, with no shielding, at different distances from the exterior surface of the drum. At 3 m (9.8 ft.) from the drum surface, the exposure rate is [[ ]]$^{PROP/ECI}$. This indicates that there must be adequate shielding or shadow shielding within the cask loading bay area to limit the exposure to workers.

Table 4b.2-4 presents MicroShield results for the same waste drum with an [[ ]]$^{PROP/ECI}$ from the drum exterior surface. A [[ ]]$^{PROP/ECI}$ side shield were analyzed. The results indicate that a side shield or top hat shield around a waste drum significantly decreases the exposure rate to the worker.

4b.2.2 HCF VENTILATION DESCRIPTION

The HCF ventilation system provides the heating, cooling, and ventilation required to condition the air and maintain radiological confinement in the facility. The system is comprised of both safety-related and nonsafety-related portions. The safety-related system, including specific safety-related/engineered safety feature system description and requirements, is discussed in Chapter 6b. The nonsafety-related system is discussed in Chapter 9b.

Table 4b.2-1
Exposure Rate for the Target Processing Canyon 30 kW-25-Day Burnup with 6-Hour Decay Time

Case	Exposure Rate (mR/hr)	
	1 Target	6 Targets
94 in. (239 cm) from target – no shielding	[[	[[
164.4 DI	]]PROP/ECI	]]PROP/ECI

Abbreviations: kW = kilowatt(s) | mR = milli-Roentgen | hr. = hour(s) | in. = inch(es) | cm = centimeter(s) | DI = density inches

Table 4b.2-2
Exposure Rate for the Waste Storage Canyon with a Waste Drum Filled with Nominal Density Concrete 30 kW-25-Day Burnup

Case	Exposure Rate 15 Targets (mR/hr)		
	6 months decay	1 year decay	2 years decay
59.6 in (151 cm) from drum Concrete matrix Nominal density concrete side shield (140.0 DI)	[[ ]] PROP/ECI	[[ ]] PROP/ECI	[[ ]] PROP/ECI

Abbreviations: kW = kilowatt(s) | mR = milli-Roentgen | hr. = hour(s) | in. = inch(es) | cm = centimeter(s) | DI = density inches

Table 4b.2-3
Exposure Rate with a Waste Drum Filled with Nominal Density Concrete – No Shielding
30 kW-25-Day Burnup

Case	Exposure Rate 15 Targets (mR/hr)		
	6 months decay	**1 year decay**	**2 years decay**
Drum surface	[[	[[	[[
39.4 in. (1 m) from drum surface			
118.1 in. (3 m) from drum surface	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$	]]$^{PROP/ECI}$

Abbreviations: kW = kilowatt(s) | mR = milli-Roentgen | hr. = hour(s) | in. = inch(es) | m = meter(s) | DI = density inches

Table 4b.2-4
Exposure Rate with a Waste Drum Filled with Nominal Density Concrete Fe Side Shield
30 kW-25-Day Burnup

Case	Exposure Rate 15 Targets (mR/hr)		
	6 months decay	**1 year decay**	**2 years decay**
12 in. (30 cm) from drum 15 cm Fe shield (46.4 DI)	[[	[[	[[
12 in. (30 cm) from drum 30 cm Fe shield (92.8 DI)	]]PROP/ECI	]]PROP/ECI	]]PROP/ECI

Abbreviations: kW = kilowatt(s) | mR = milli-Roentgen | hr. = hour(s) | in. = inch(es) | cm = centimeter(s) | Fe = iron | DI = density inches

4b.3 RADIOISOTOPE EXTRACTION

Background

The MCP (Rotsch et al., 2015; Vandegrift, 2016) is used to extract Mo-99 from the irradiated LEU target foils. The MCP was chosen for several reasons including:

- LEU dissolution time is a few hours using the acidic process.
- MCP and the Cintichem process are well developed chemical separation techniques.
- Cintichem produced Mo-99 product has been accepted in the past by U.S. generator companies.
- A drug master file existed in the past for the Cintichem process.
- The U.S. Department of Energy (DOE), Sandia National Laboratories (SNL), and Los Alamos National Laboratory (LANL) invested significant resources in the 1990s to re-engineer the Cintichem process.
- Argonne National Laboratory (ANL) has performed significant research into the development of the MCP.
- Eden's development team has significant expertise in the Cintichem process from work performed at SNL, Albuquerque, in the 1990s.

The Cintichem process was developed by Union Carbide in the 1970s at their U.S. Nuclear Regulatory Commission Licensed Cintichem facility in Tuxedo, New York, to process irradiated high-enriched uranium (HEU) targets for the separation of Mo-99. The Cintichem-type target was an approximately 1-in. diameter stainless-steel tube internally plated with 20 to 30 g (0.71 to 1.1 ounces [oz.]) of HEU in the form of uranium dioxide (UO_2), and irradiated in their 5 megawatt-thermal (MWt), pool-type research reactor. The extraction process utilized a sulfuric acid (H_2SO_4)/HNO_3 solution to dissolve the UO_2 coating within the sealed stainless-steel tube. After dissolution, alpha-benzoin oxime (ABO) was added to the solution to cause the Mo to precipitate as a flocculent, which was then recovered through filtration. The Mo loaded ABO was then washed, dissolved into a Mo solution, and purified using several chemical filtering steps. Cintichem ceased their Mo operations in the late 1980s. The DOE arranged for Cintichem to transfer their technology to SNL and LANL for future use.

During the 1990s, the DOE funded SNL and LANL to become a backup U.S. supplier of Mo-99. With the help of key Cintichem staff members, the process was re-engineered for use at SNL's Technical Area V (TA-V) nuclear facilities. The Annular Core Research Reactor and the Hot Cell Facility were reconfigured to use HEU Cintichem-type targets and processing methodology. LANL produced the HEU targets at their Chemical and Metallurgical Research Facility. Several targets were irradiated and processed successfully at TA-V.

The DOE funded program was suspended in the late 1990s, with the expectation that the new Canadian Maple X reactors would be online within a few years to accommodate global demand for Mo-99. However, the Maple X reactors were never brought online, and Canada discontinued its development work in 2008.

The MCP was developed as part of a worldwide effort, led by the United States, to eliminate the use of HEU in Mo-99 production. However, the LEU dissolution process required significantly greater quantities of acid to accommodate the larger quantity of U. ANL developed the MCP to

address this issue. The MCP adds a step after dissolution to separate the Mo from the solution, using a titania column, which has an affinity for Mo. The Mo is then redissolved from the column and the nominal Cintichem process used to purify the final product.

To use LEU instead of HEU with the MCP, a new target design was required to accommodate the greater mass of U. The current target design is based on work performed by ANL and Y-12 National Security Complex to produce LEU foils.

Summary Description

The target design is presented in Chapter 4a. The target fabrication process is described in Subsection 4b.4.2. At full power, the LEU targets in the all-target reactor core operate at an average power level of 30 kWt up to a maximum burnup level of 0.75 MW-days. After irradiation, targets are transferred underwater in the transfer canal to the HCF target processing canyon. The fission-produced radioisotopes, in particular Mo-99, I-131 and Xe-133, are separated from the irradiated LEU and the other fission products and purified for acceptable use by the customer. This is performed by dissolving the irradiated U from up to six targets in an acid bath in a dissolver unit within one of the four designated dissolver box SCBs and performing several chemical steps to separate and purify the desired radioisotopes. The remaining U, fission product, and actinide solution is transferred to other SCBs for separation of the LEU as a solid oxide using a UREX process and solidification of the fission product and actinide solution into a concrete grout for future disposal at a LLW site as Class-C waste.

During irradiated target handling, LEU foil separation from the cladding, LEU foil dissolution, the UREX process, and waste handling, the fission products continue to decay by beta and gamma-ray emission, resulting in heat being generated in the intrinsic material associated with the fission products. All the processing hardware is designed and operated with the heat load requirements integrated into the design and operation of the system; this is further described in Chapter 5b. For beta emission, it is assumed that all the energy is deposited locally in the intrinsic material because the linear energy transfer (LET) is large. For gamma-ray emission, some of the energy escapes the intrinsic material because the LET is small.

The cooling requirements, described in Chapter 5b, for each of the activities in the SCBs are dependent on the activity and the fission product inventory and time duration for the activity. Some activities only require natural convection air cooling, while others may require nitrogen cooling or a water bath.

4b.3.1 IRRADIATED TARGET STAGING

Targets are irradiated in the reactor for up to 25 days at full power, removed from the reactor, and transferred to the HCF for processing using the target transfer system described in Chapter 9a. With the reactor operating at full power (1.8 MWt), the target average power is 30 kWt. Processing 30 targets per week produces the current U.S. demand for Mo-99, approximately 5000 6-day Ci per week. Several times a week the reactor is briefly shut down for irradiated target transfer to the HCF target processing canyon for Mo-99 processing in a batch mode. With the reactor shut down and the target transfer system at its staging location in the reactor pool, the target handling system, described in Chapter 9a, is used to move the identified irradiated targets from the reactor core to the target transfer system’s irradiated target carrier and transfer basket. Fresh targets are then taken from the fresh target carrier and transfer basket using the target handling system and moved to the reactor core in the exact locations where irradiated targets were removed. The complete target handling process is expected to take less than one

hour. The reactor is then restarted and taken to full power operation. The target transfer system moves the target transfer basket and carriers back to their staging location beneath the target receipt box in the HCF target processing canyon.

The irradiated targets are allowed to cool for a minimum of 4 hr. in the transfer canal before the start of processing. When ready, the irradiated target carrier and transfer basket are raised into the target receipt box and the irradiated targets removed from the carrier and staged for their initial QC verification and validation acceptance. The target flutes and centering rod are removed from each target in the target receipt box. The targets are separated into groups and transferred to the individual dissolver boxes for processing. The maximum number of targets that can be in the target receipt box at any one time is 120. This is equal to the combined total number of targets that could be in the irradiated target carrier (60) and the fresh target carrier (60) at any given time. The target receipt box is the interface location for both fresh and irradiated targets. Activation targets are also passed through the target receipt box for processing outside of the HCF target processing canyon in a separate AIP area in the basement of the HCF.

4b.3.2 IRRADIATED TARGET DISSOLUTION

Two independent dissolver unit systems are in each dissolver box, with only one being used to dissolve target foils at any given time. The number of dissolver boxes in the target processing canyon is four, with two additional backup SCBs available as R&D boxes. Each dissolver system can dissolve up to six target foils at one time. Up to 24 target foils may be in the process of being dissolved at any given time in the target processing canyon. The number of targets in a dissolver box at any given time is 24, assuming that targets are in transition from the target receipt box to the appropriate dissolver box. Only six target foils can be dissolved in a dissolver box at one time.

In the dissolver box, targets are disassembled by cutting and removing the outer cladding to gain access to the LEU foil. The LEU foils are removed from the target Al cladding and placed into a dissolver unit, as shown in Figure 4b.3-1. The dissolver unit is sealed, and formal work instructions and procedures are followed to dissolve the LEU metal foils using HNO_3 and [[ ]]$^{PROP/ECI}$. The dissolution process may take up to 4 hr. to complete.

Equations 4b.3-1 and 4b.3-2 show the two dissolution reactions for U metal and HNO_3 to form $UO_2(NO_3)_2$, water (H_2O) and either nitrogen dioxide (NO_2) or nitric oxide (NO) (Neal et al., 2023; Neal et al., 2024). Equation 4b.3-3 shows the reaction of Ni metal and HNO_3. For U, both reactions occur. Their relative reaction rates depend on the molar concentration of the acid. An acid concentration of 8 molar (M) (8 M = 8 g-mol of HNO_3 per L of solution) is the crossover between reaction rates, with higher molarity allowing for greater reactions described by Equation 4b.3-1. The process described in this chapter in the EMIF uses [[ ]]$^{PROP/ECI}$. [[ ]]$^{PROP/ECISRI}$.

$$U + 8HNO_3 \rightarrow UO_2(NO_3)_2 + 6NO_2 + 4H_2O + 1019.7 \text{ kJ/g-mol U} \quad \text{(Equation 4b.3-1)}$$

$$U + 4HNO_3 \rightarrow UO_2(NO_3)_2 + 2NO + 2H_2O + 1159.9 \text{ kJ/g-mol U} \quad \text{(Equation 4b.3-2)}$$

$$Ni + 2⅔HNO_3 \rightarrow Ni(NO_3)_2 + ⅔NO + 1⅓H_2O + 260.9\ kJ/g\text{-}mol\ Ni \quad \text{(Equation 4b.3-3)}$$

During the dissolution process, [[ ]]PROP/ECI to maintain an overpressure on the order of tens of pounds per square inch (psi). [[ ]]PROP/ECI, which is then condensed within the dissolver unit and added back into the solution (Neal et al., 2023; Neal et al., 2024). Equation 4b.3-4 shows the NO to NO_2 reaction. Equation 4b.3-5 shows the formation of [[ ]]PROP/ECI from reaction 4b.3.4.

[[ ]]PROP/ECI (Equation 4b.3-4)

[[ ]]PROP/ECI (Equation 4b.3-5)

Equation 4b.3-6 shows the overall HNO_3 and [[ ]]PROP/ECI for the dissolution of U. Equation 4b.3-7 shows the overall HNO_3 and [[ ]]PROP/ECI for the dissolution of Ni. As the metal foil is dissolved, the HNO_3 concentration decreases.

[[ ]]PROP/ECI (Equation 4b.3-6)

[[ ]]PROP/ECI (Equation 4b.3-7)

For a [[ ]]PROP/ECI/SRI U foil, approximately [[ ]]PROP/ECI are consumed. Some HNO_3 remains in the solution after dissolution of the U. [[ ]]PROP/ECI.

The dissolution rate of the U metal foil is logarithmically proportional to the molarity of the HNO_3. Figure 4b.3-2 shows the dissolution rate versus the HNO_3 molarity, up to the azeotrope value of 15.6 M (Delegard et al., 2008).

For a [[ ]]PROP/ECI/SRI, the dissolution time is expected to be 1 – 2 hr., with a starting HNO_3 molarity of [[ ]]PROP/ECI. The amount of heat given off from the exothermic reaction would be about [[ ]]PROP/ECI per target foil. For a dissolution time of 2 hr., the heat rate would be about [[ ]]PROP/ECI per target.

The fission product decay heat rate and chemical reaction heat rate impose cooling requirements on the dissolver unit design. This cooling is provided through the condenser coil within the unit and external cooling of the dissolver vessel. Chapter 5b provides the dissolver vessel cooling requirements.

4b.3.3 SEPARATION OF NOBLES AND HALOGENS FROM THE FISSION PRODUCT SOLUTION

After the dissolution of the LEU metal foils is completed, the noble gases and halogens are evacuated from the dissolver unit using the FGDS. A FGDS is associated with each dissolver unit in a dissolver box. The purpose of the FGDS is to remove the noble gases and halogens from the dissolver unit after LEU metal foil dissolution. The system also incorporates an iodine trap that is removed after processing. The iodine trap is staged for later processing of the I-131 for sale or allowed to decay in the dissolver box in preparation for disposal. After a sufficient decay period (several weeks) the FGDS is purged into the dissolver box ventilation. The FGDS components may be reused or staged for disposal in the waste packaging box. The system functions by liquid nitrogen cooling of sorption pumps that are located within the dissolver box. Liquid nitrogen is supplied by portable dewars that are located in the work area near the dissolver box workstation outside of the target processing canyon.

Activities performed as part of the FGDS include the following:

- FGDS set up and leak detection prior to use.
- Liquid nitrogen cooling of FGDS sorption pump components.
- Evacuation of the dissolver vessel after dissolution.
- FGDS isolation and iodine trap removal.
- FGDS decay.
- FGDS purge and preparation for reuse.

4b.3.4 MO-99 SEPARATION FROM FISSION PRODUCT SOLUTION

After the dissolver unit is evacuated, the FGDS is isolated from the dissolver unit and the solution passed through a titania (titanium oxide) column to separate and collect the Mo from the solution. The dissolver unit is rinsed with water several times through the titania column. Some fission products are entrained on the titania column due to the column's efficiency (Stepinski, Youker, & Vandegrift, 2014; Servis et al., 2023). The Mo is removed from the titania column by washing it with a caustic solution into a sealed container that is transferred to the purification box for further Cintichem processing.

The remaining solution is staged in a sealed container in the dissolver box for transfer to the UREX box for LEU separation. The container is expected to hold a few liters and is designed with passive cooling. The LEU is in the form of $UO_2(NO_3)_2$. Actinides and fission products, except for the noble gases, halogens, and Mo, are also in the solution.

4b.3.5 MO-99 PURIFICATION AND PACKAGING

The Mo-99 is purified for marketing in further steps by using the MCP within a purification box (Attrep, Miller, & Quintana, 1995). The MCP takes several hours to accomplish. The product is a highly pure Mo solution from which a QC sample is drawn.

The MCP steps are as follows:

- [[ ]]$^{PROP/ECI}$.

- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]PROP/ECI.
- [[ ]]=PROP/ECI.
- [[ ]]PROP/ECI.
- Filter final product solution to remove any particulates.
- Draw QC sample from product solution.

The QC sample and the Mo solution are moved to the packaging box. In the packaging box, the Mo solution is loaded in the shield portion of a DOT Type B Mo-99 shipping container. The QC sample is placed in a specially designed shield for transfer to the QC laboratory within the HCF. Both packages are removed from the packaging box. The shielded Mo-99 solution is sent to the product shipping area and prepared for shipment.

4b.4 SPECIAL NUCLEAR MATERIAL PROCESSING AND STORAGE

4b.4.1 PROCESSING OF IRRADIATED SPECIAL NUCLEAR MATERIAL

After several days of decay, the solution containing the LEU in the form of $UO_2(NO_3)_2$, the remaining fission products, and the actinides is transferred to the UREX box for LEU separation. The LEU is in the form of $UO_2(NO_3)_2$. Actinides and fission products, except for the noble gases, halogens, and Mo, are also in the solution.

4b.4.1.1 UREX Processing and Separation of LEU

The $UO_2(NO_3)_2$/fission product/actinide solution container is transferred to the UREX box for solvent extraction processing to remove the LEU from the solution. Several solution containers from the dissolver boxes can be staged together for processing in the UREX box. It is expected that the solution for up to 30 dissolved target foils can be staged at one time in the UREX box and processed.

The UREX solvent extraction process is used in one or two UREX boxes to remove the $UO_2(NO_3)_2$ from the waste solution (raffinate) and refine it to remove all the actinides and fission products. Some of the LEU may remain in the raffinate after the solvent extraction process, depending on the efficiency of the process. After processing, the raffinate is sent to the waste packaging box. The $UO_2(NO_3)_2$ material is dried and formed into a uranium oxide (U_3O_8) powder material through a calcination process.

The UREX process (Rudisill and Daniel, 2023; Rudisill, 2023) includes the chemicals TBP and dodecane, which are recycled and reused from batch to batch. The process involves several mechanical centrifugal contactors that are staged to extract and purify the $UO_2(NO_3)_2$ from the solution and reclaim the TBP and dodecane for reuse. The number of stages is optimized to recover greater than 99.99 percent of the LEU. The decontamination factors for most of the fission products are greater than 10^8 (Rudisill and Daniel, 2023; Rudisill, 2023). The stages are arranged such that most of the fission product/actinide raffinate solution is separated early in the process and is isolated from the other stages to reduce the radiation exposure to the equipment.

The purified LEU, in the form of $UO_2(NO_3)_2$, is transferred to a calcination station within an SCB in the target processing canyon or removed from the target processing canyon though a packaging box for processing in a hood in the target fabrication area.

The fission product/actinide raffinate solution is transferred to the waste packaging box for solidification.

4b.4.1.2 Fission Production Solution Conversion to Solid Grout LLW

The several liters of remaining fission product/actinide raffinate solution are combined with other liquid waste from the Mo-99 MCP in the batch. The liquids are placed in the waste drum and grouted with a cement and sand mixture. The amount of target waste that can be loaded in each waste drum is estimated to result from processing 15 targets.

When the grouting process is complete, the waste drum is approximately two-thirds filled with grout. The waste drum is then filled with other solid waste from the MCP, including the cladding hulls, titania columns, and iodine traps, and sand. When filled, the drum lid is sealed. The drum lid is vented using a small filter connection. The waste drum is staged on a waste storage cart

and then transferred to the shielded waste storage canyon using an elevator. In the waste storage canyon, the drums are staged for decay for a minimum of 6 months and then sent to the Class C LLW disposal site using an approved Type B shipping container that can hold up to 10 drums in one shipment.

4b.4.1.3 LEU Calcination Process

The highly purified $UO_2(NO_3)_2$ material is dried and formed into a U_3O_8 powder material through a calcination process. The U_3O_8 powder material is packaged into a custom container and sent to the packaging box. At the packaging box, surface contamination on the container is removed and the container is surveyed to verify external contamination release limits are met. The U_3O_8 container is removed from the packaging box and taken to the SNM storage area for storage. The U_3O_8 container may contain [[ ]]PROP/ECI/SRI targets worth of U [[ ]]PROP/ECI/SRI LEU is equivalent to about [[ ]]PROP/ECI/SRI U-235 in the target reference design). The volume of U_3O_8 powder is estimated to be about [[ ]]PROP/ECI/SRI.

The U_3O_8 powder is staged in its packaged container with other U_3O_8 containers in the segregated space of the SNM storage area. After several months of collection, the U_3O_8 is processed in the target fabrication area to form U metal ingots, then into U metal foils, and then into complete targets.

4b.4.2 PROCESSING OF UNIRRADIATED SPECIAL NUCLEAR MATERIAL

4b.4.2.1 SNM Storage

SNM storage is managed within the HCF. SNM storage is utilized to sequence the steps in target fabrication and to maintain an inventory of LEU and targets that are ready for irradiation. The SNM storage area stores, in a secure and criticality safe configuration:

- Fully assembled and ready to irradiate fresh targets.
- U_3O_8/UO_2 powder, fresh from the supplier and recycled.
- U metal ingots that have been cast with the proper alloy content.
- U metal foils that have been rolled, cut to size, shaped, and Ni coated.

At any given time, there may be materials in any of these four forms in the SNM storage area. The forms are segregated and maintained in custom designed containers, drawers, and racks that are designed to be criticality safe in both dry and flooded conditions. Minimal moderator materials are used in the SNM storage area and designed into containers, drawers, and racks. The Nuclear Criticality Safety Program is described in Chapter 6b. The Material Control and Accountability Program is described in Chapter 12.

Fully assembled and QC inspected fresh targets are stored in the SNM storage area. As the targets are needed for irradiation, they are transferred from the SNM storage area to the target receipt box in the target processing canyon via a cart that holds up to 60 targets. The cart is designed to be criticality safe in both dry and flooded conditions. The amount of U in each target in the target reference design is [[ ]]PROP/ECI/SRI of LEU, equivalent to [[ ]]PROP/ECI/SRI U-235, assuming an enrichment of 19.75 percent.

The other types of U material forms identified above are used as needed in the target fabrication area.

4b.4.2.2 Target Fabrication

The target fabrication area maintains all the target fabrication equipment to perform the fresh target fabrication activities described briefly in Subsection 4b.1.1.6. The area accommodates all the necessary processes to recycle the U_3O_8 extracted from the UREX process and fresh material from stock to completely fabricate the required number of targets for full U.S. Mo-99 production.

These activities are shown in Figure 4b.4-1 and include the following:

- SNM blending.
- Oxide to metal reduction, metal ingot casting.
- Ingot to foil production, cutting and shaping, Ni foil plating.
- Foil to target production using the hydroforming process.

Each of these activities has unique and redundant equipment with the goal of producing up to 1500 targets per year in the HCF. The activities are performed in batch-type campaigns to allow for efficient production of high-quality targets.

The target fabrication activities described below will be licensed under a separate Title 10 of the Code of Federal Regulations (10 CFR) Part 70 license as part of the Operating License.

4b.4.2.2.1 SNM Blending

SNM blending is performed in the target fabrication area. The process flow for the SNM blending is shown in Figure 4b.4-2. The U-235 enrichment of recycled LEU has been reduced through burnup in the reactor. An SNM source provides 19.75 percent enriched U to make up for this loss. Blending may occur with LEU metal or LEU oxide powder. Blending operations are performed in a ventilation hood.

The preferred option for the EMIF is to recycle LEU. The U-235 burnup from irradiating a target at 30 kWt for 21 days is approximately [[ ]]$^{PROP/ECI/SRI}$. Thus, for every cycle, the U-235 mass in a [[ ]]$^{PROP/ECI/SRI}$ LEU target decreases by [[ ]]$^{PROP/ECI/SRI}$. To maintain enough reactivity in the reactor core, the U-235 loss is made up by blending additional fresh 19.75 percent enriched LEU with the U_3O_8, prior to the oxide to metal reduction activity. To maintain the same quantity of U-235 per target, an additional [[ ]]$^{PROP/ECI/SRI}$ of 19.75 percent LEU is added to each target during the blending operation.

4b.4.2.2.2 Oxide to Metal Reduction, Metal Ingot Casting

Oxide to metal reduction is performed in the target fabrication area. The process flow for the oxide to metal reduction and metal ingot casting is shown in Figure 4b.4-3. A ventilation hood is used to accomplish the [[ ]]$^{PROP/ECI}$.

To produce U metal foils, the U_3O_8 is converted to a metal form for rolling into U metal foils.
[[

]]PROP/ECI

[[
]]PROP/ECI (Equation 4b.4-1)

[[

]]PROP/ECI/SRI QC samples are taken to verify both elemental and isotopic inventory in the ingot. The finished U ingot is packaged and transferred to the SNM storage area. Other U materials and trimmings are collected, inventoried, and transferred to the SNM storage area for later LLW disposal or recycling. The oxide to metal reduction campaign is expected to occur about four times per year.

4b.4.2.2.3 Ingot to Foil Production, Cutting and Shaping, Ni Foil Plating

LEU metal ingot to metal foil production is performed in the target fabrication area. A rolling mill, salt bath, furnace, and shears are used to form the LEU metal ingots into metal foils (Wiencek, Vandegrift, & Bakel, 2009; Vandegrift, 2016). The foils are then heat treated, shaped, and Ni coated in preparation for target fabrication.

Metal foils are produced by rolling mill operations on the correctly sized U metal ingot. To produce a [[ ]]PROP/ECI/SRI LEU foil with the correct width and length, a foil with a uniform thickness of [[ ]]PROP/ECI/SRI is desired. Rolling is performed using 2-high and 4-high rolling mills in a normal air environment. Hot or warm rolling is performed on the 2-high mill. Cold rolling is performed on the 4-high mill (Wiencek, Vandegrift, and Bakel, 2009; Vandegrift, 2016). Hot or warm rolling occurs with the ingot at a temperature of 200 degrees Celsius (°C) (392 degrees Fahrenheit [°F]) or greater. Hot plates, a tube furnace, or a molten salt bath is used to maintain the temperature of the ingot, after several passes through the 2-high rolling mill. Every pass through the mill reduces the thickness by 5 to 10 percent. After the ingot has been transformed into a foil about 50 mils (0.127 cm) in thickness, cold rolling on the 4-high rolling mill begins. Again, every pass reduces the thickness by 5 to 10

percent until the final foil specification thickness is reached. As the foil is reduced in thickness, its length increases. For an initial ingot of [[ ]]PROP/ECI/SRI, the foil is cut in half several times to allow the foil length to be maintained in a manageable state. Approximately [[ ]]PROP/ECI/SRI.

The final foils are trimmed to the proper width and length and heat treated in batches. The purpose of the heat treatment is to develop small grains in the foil and allow the foil to be malleable. The heat treatment involves two processes identified as beta quenching and alpha annealing (Angerman, Huntoon, & McDonnell, 1959; Wiencek, Vandegrift, & Bakel, 2009). The beta quenching treatment first raises the temperature of the foil into the beta phase (660°C to 770°C [1120°F to 1418°F]), followed by a quenching in water or oil. The alpha annealing raises the temperature of the foil into the alpha phase (about 380°C [716°F]) followed by slow cooling.

The foil rolling, foil trimming, and heat treatment processes are shown in Figure 4b.4-4. QC samples are taken on the foil trimmings to verify the grain structure in the foils. Thickness measurements are taken on each foil to verify their uniformity. Dimension and mass measurements are taken on each foil to verify they meet the specification requirements. The finished LEU foils are packaged and transferred to the SNM storage area. Other U materials and trimmings are collected, inventoried, and transferred to the SNM storage area for later LLW disposal or recycling. The foil rolling campaign is expected to occur about [[ ]]PROP/ECI.

After the foils are shaped into cylinders, they are cleaned to remove any oxide (UO_2) formation and plated with 10 µm (0.39 mils) of Ni (Olivares et al., 2015). These processes are shown in Figure 4b.4-5. The Ni plating provides a recoil barrier so that the fission fragments emitted from the surface of the LEU foil during irradiation are deposited within the plating (Vandegrift, 2016). The Ni plating also provides a protective layer for the LEU foil to limit oxidation during storage prior to use. QC thickness measurements are taken on each foil to verify their uniformity. QC dimension and mass measurements are taken on each foil to verify they meet the specification requirements. The finished and plated LEU cylindrical foils are packaged and transferred to the SNM storage area. Other U materials and trimmings are collected, inventoried, and transferred to the SNM storage area for later LLW disposal or recycling. The foil shaping and Ni plating campaigns are expected to occur about [[ ]]PROP/ECI.

4b.4.2.2.4 Foil to Target Production Using the Hydroforming Process

Target production is performed in the target fabrication area. LEU metal foils are clad with Al tubing using a hydroforming process.

The process flow diagram for the target fabrication process is shown in Figure 4b.4-6. A target is made up of a cylindrically shaped LEU metal foil sandwiched between an inner and outer Al-6061 tube using a hydroforming process. The hydroforming process results in the foil being in intimate contact with the cladding so that a high degree of thermal contact is maintained during irradiation. The foil is not bonded to the cladding, allowing for it to be separated from the cladding material during processing. After hydroforming, the inner cladding maintains a [[ ]]PROP/ECI to ensure intimate contact through the lifecycle of the target.

The basic design description of a target is shown in Figure 4b.4-7. The Al tubing is commercially available Al-6061. The inner cladding tubing is 0.875 in. (2.22 cm) outer diameter by [[ ]]PROP/ECI wall. The outer cladding tubing is 1.0 in. (2.54 cm) outer diameter by [[

]]PROP/ECI wall. A target is formed by first placing the cylindrically shaped U foil inside the outer tube cladding that has been cut to a specified length greater than 60 cm (23.6 in.), as shown in Figure 4b.4-8. The inner tube cladding is inserted into the target assembly. [[

]]PROP/ECI

After hydroforming, the target assembly is trimmed to the correct length. The target is sealed at both ends using an Al fillet weld. The target is He leak tested to ensure the target meets the leak-rate specification. The outer cladding is marked with a unique QC target identification number using a laser inscription device.

QC dimensions and mass measurements are taken on each hydroformed target to verify they meet the specification requirements. The hydroformed targets are assembled with the end flutes to complete the final target assembly and are transferred to the SNM storage area.

The target hydroforming campaign is expected to occur about [[ ]]PROP/ECI. At full U.S. Mo-99 production, approximately 1500 targets are required per year.

4b.5 SUMMARY AND CONCLUSIONS

The EMIF HCF is designed to allow for safe, efficient, and continuous production of 100 percent of the U.S. demand for Mo-99 and other medical radioisotopes. The main areas of the HCF are the target processing canyon and waste storage canyon, which provide the necessary biological shielding to the worker and maintain all the SSCs necessary to receive and process irradiated targets from the RF. These areas are served by the HCF ventilation system, which maintains differential pressures and filtered exhaust to ensure controlled releases of radioactive materials to the environment. The irradiated targets are moved from the RF to the target processing canyon through the transfer canal; a unique feature of the EMIF design. The MCP employed for Mo-99 production is described in the subsections above as well as the waste processes, storage, and shipment. Fresh target fabrication is performed in the target fabrication area of the HCF, which will be licensed under a 10 CFR Part 70 application as part of the Operating License.

Potential variables, conditions, or other items that are probable subjects of a TS are provided in Chapter 14. Final TS will be provided in the Operating License Application.

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Figure 4b.1-1
Target Processing Canyon SCBs

Figure 4b.1-2
Target Processing Canyon Rendering

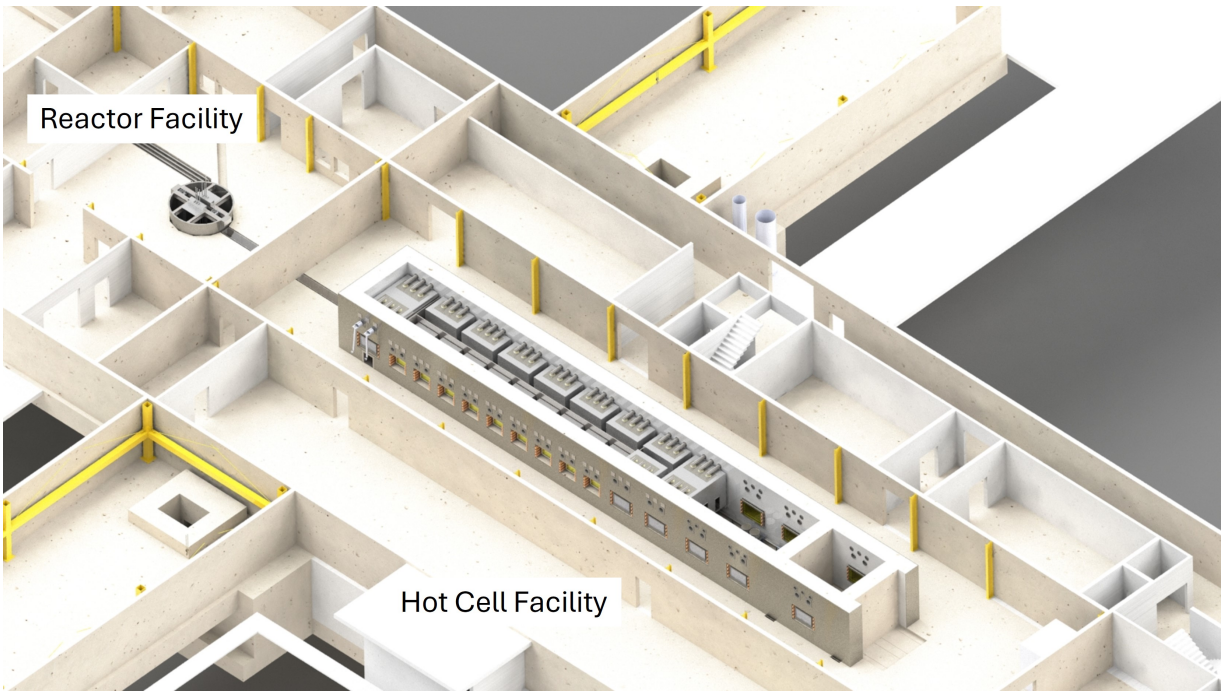

Figure 4b.1-3
Target Process Flow Diagram

[[

]]PROP/ECI

Figure 4b.1-4a
Hot Cell Facility Layout – First Floor Plan View

[[

]]PROP/ECI/SRI

Figure 4b.1-4b
Hot Cell Facility Layout – Basement Plan View

[[

]]PROP/ECI/SRI

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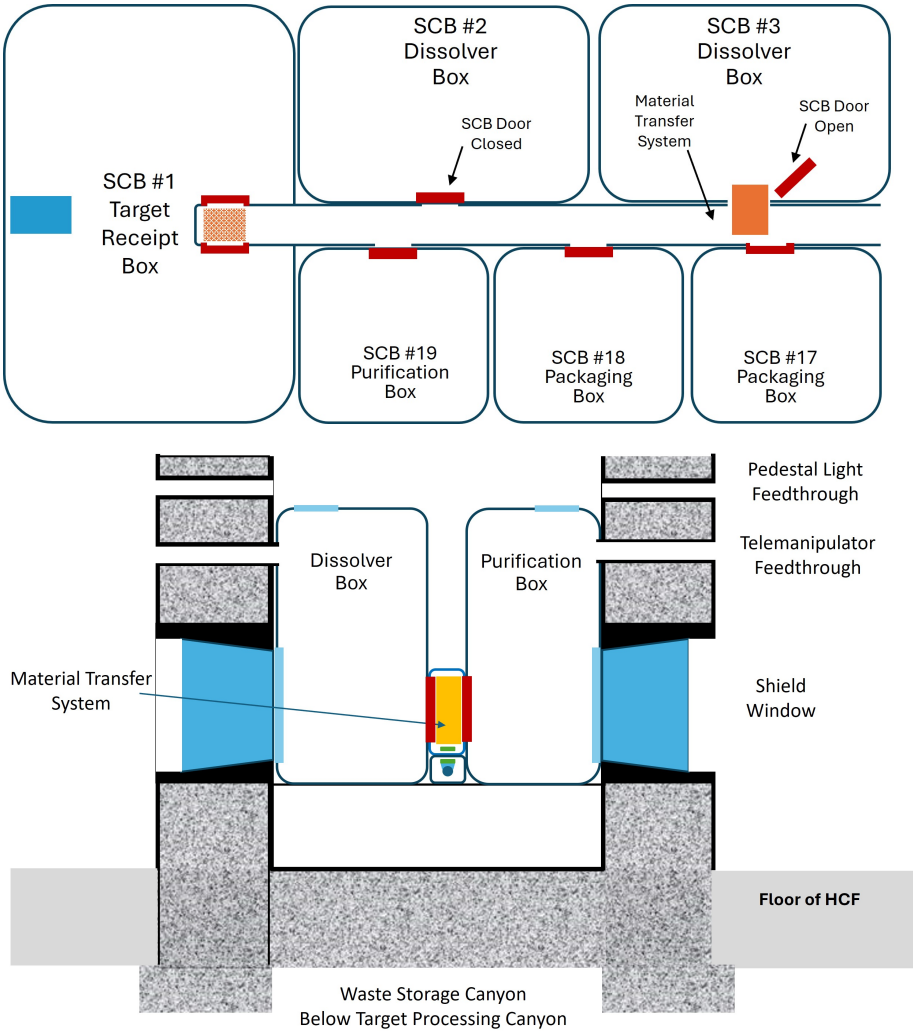
Figure 4b.1-5
SCB Material Transfer System



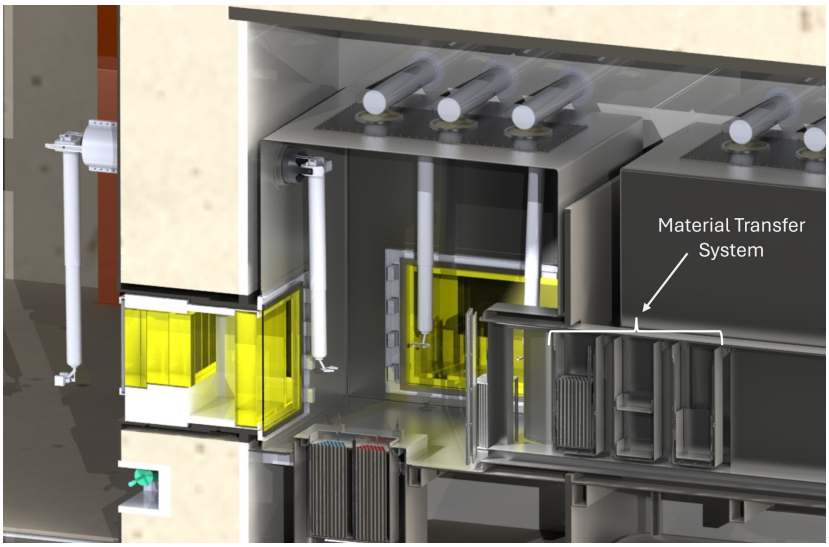


Figure 4b.1-6
Waste Storage Canyon Biological Shield

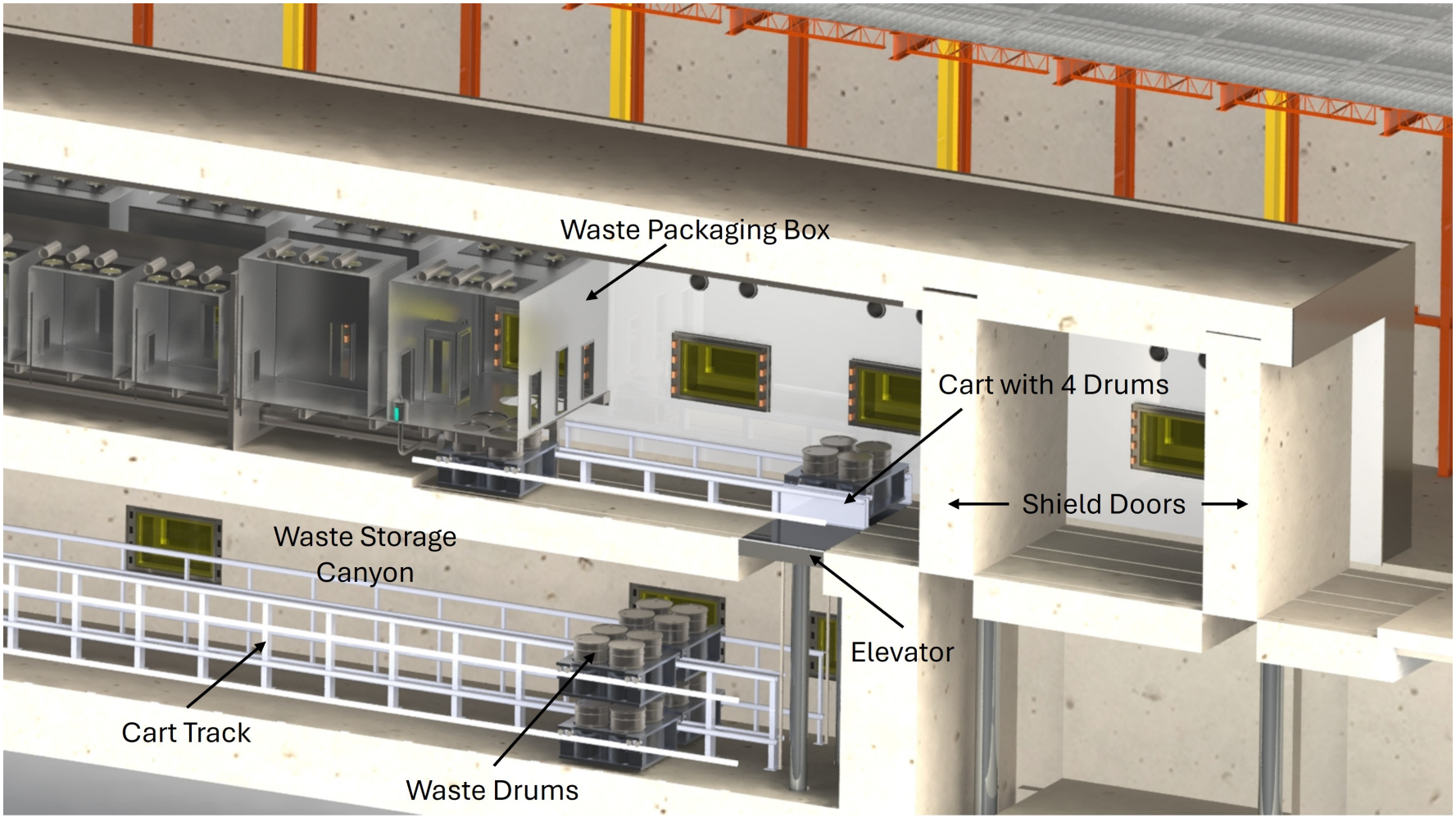


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Figure 4b.2-1
Target Processing Canyon Biological Shield

[[

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Figure 4b.2-2
Schematic of the MicroShield Biological Shield Model for the Target Processing Canyon

[[

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Figure 4b.2-3
MicroShield Model of a Waste Drum and Concrete Shield

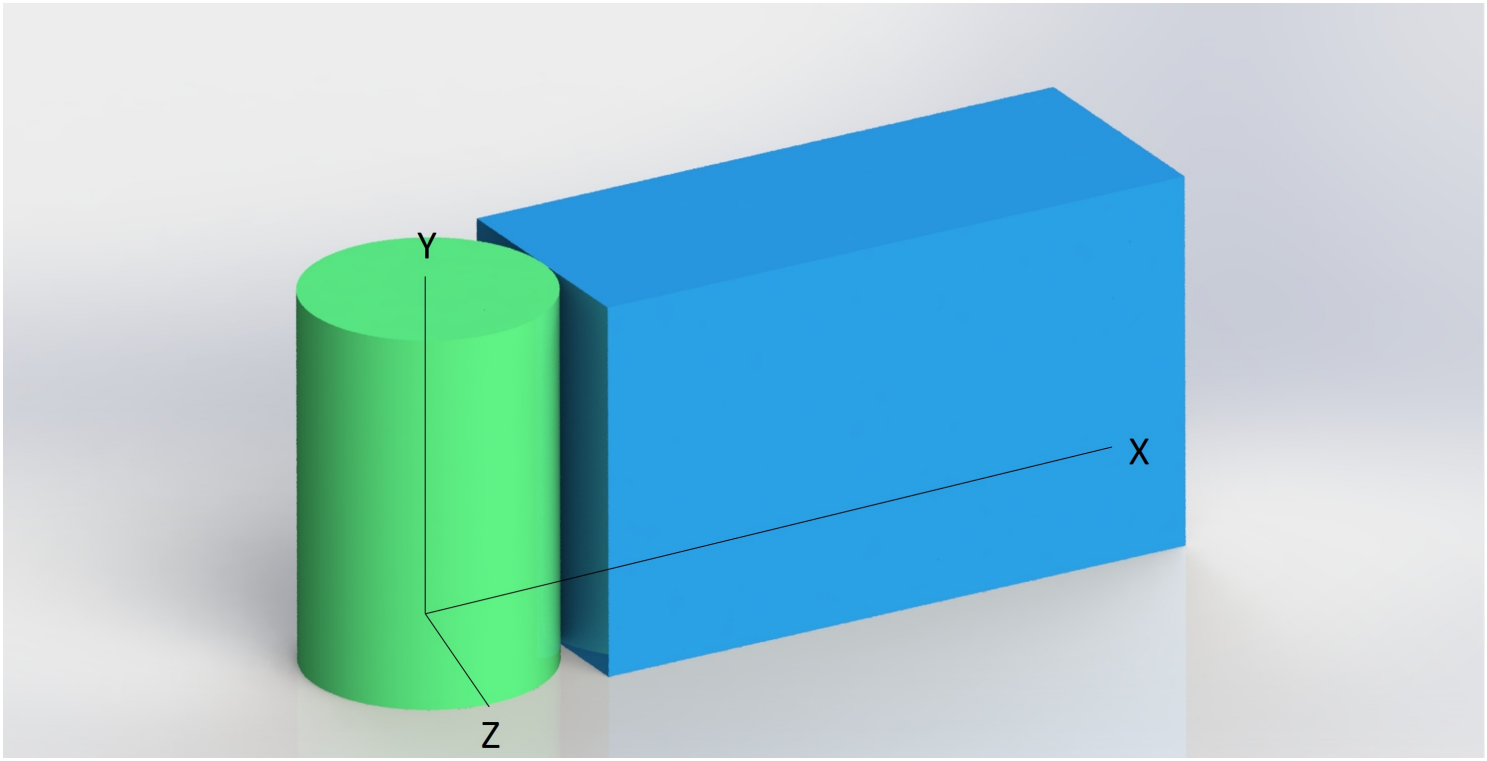

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Figure 4b.3-1
Dissolver Unit Schematic

[[

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Figure 4b.3-2
Dissolution Rate of Uranium in Nitric Acid

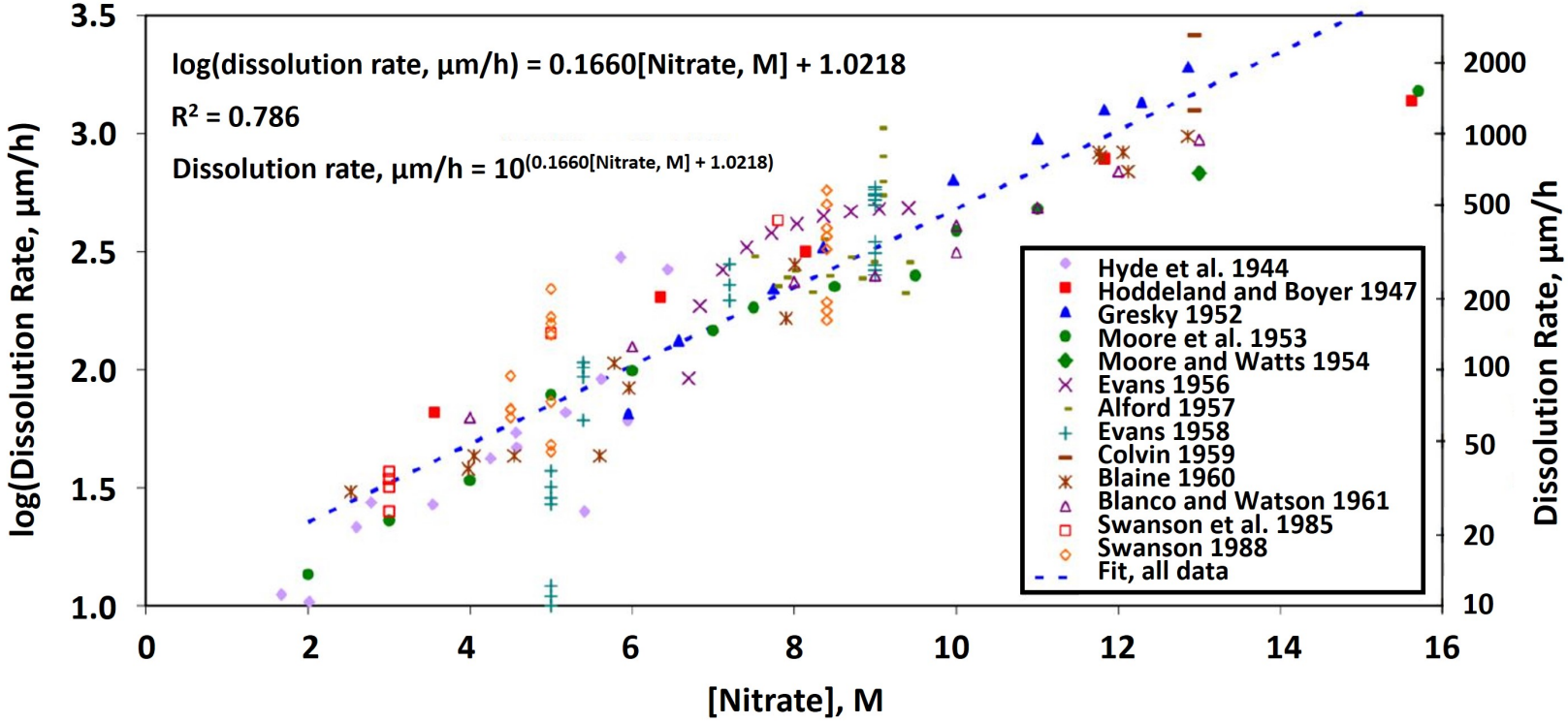

Figure 4b.4-1
Target Fabrication Activities

[[

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Figure 4b.4-2
SNM Blending Process Flow Diagram

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]]PROP/ECI

Figure 4b.4-3
Oxide to Metal Reduction Process Flow Diagram

[[

]]PROP/ECI

Figure 4b.4-4
Foil Rolling Process Flow Diagram

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]]PROP/ECI

Figure 4b.4-5
Foil Shaping and Plating Process Flow Diagram

[[

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Figure 4b.4-6
Target Hydroforming and Welding Process Flow Diagram

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Figure 4b.4-7
Target Nominal Description

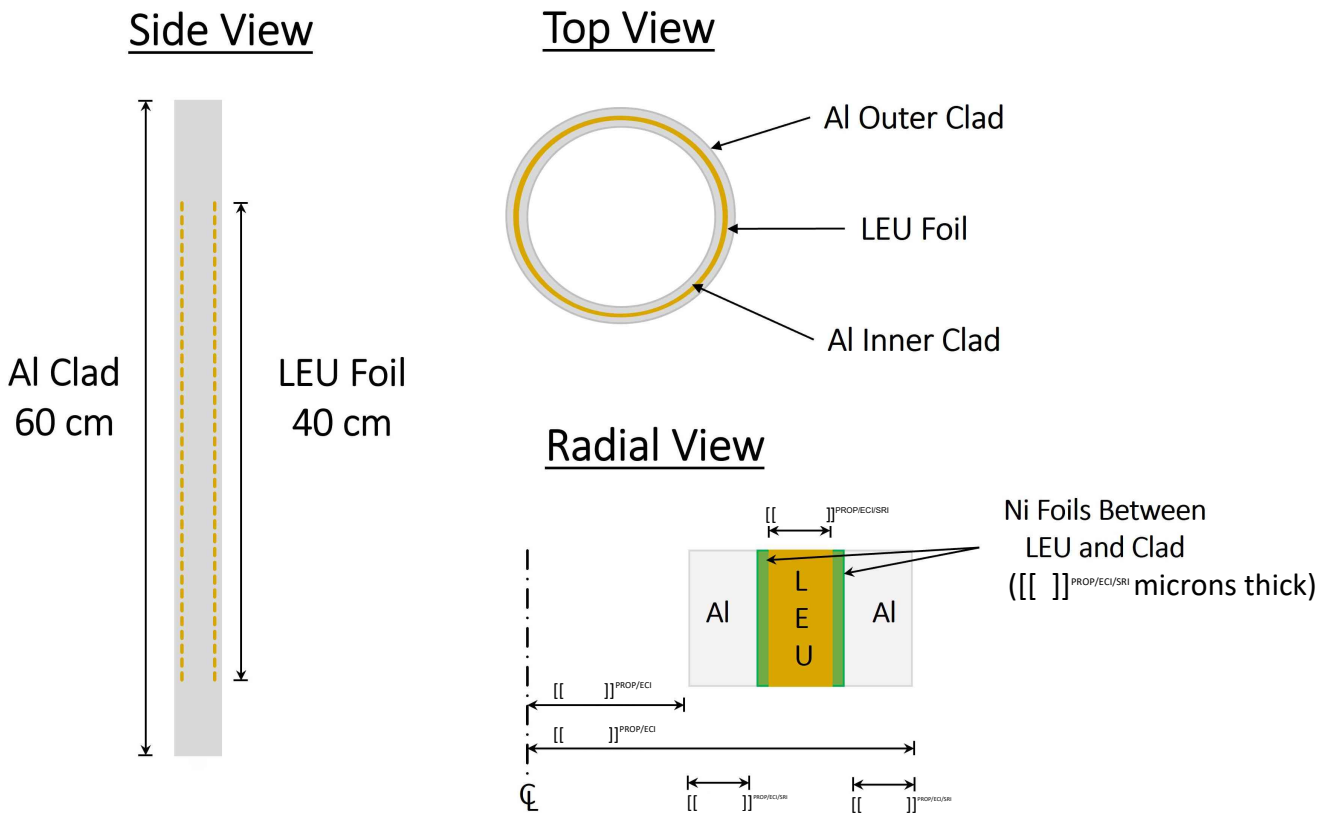

Figure 4b.4-8
LEU Metal Foil Centered Within the Outer Al Cladding

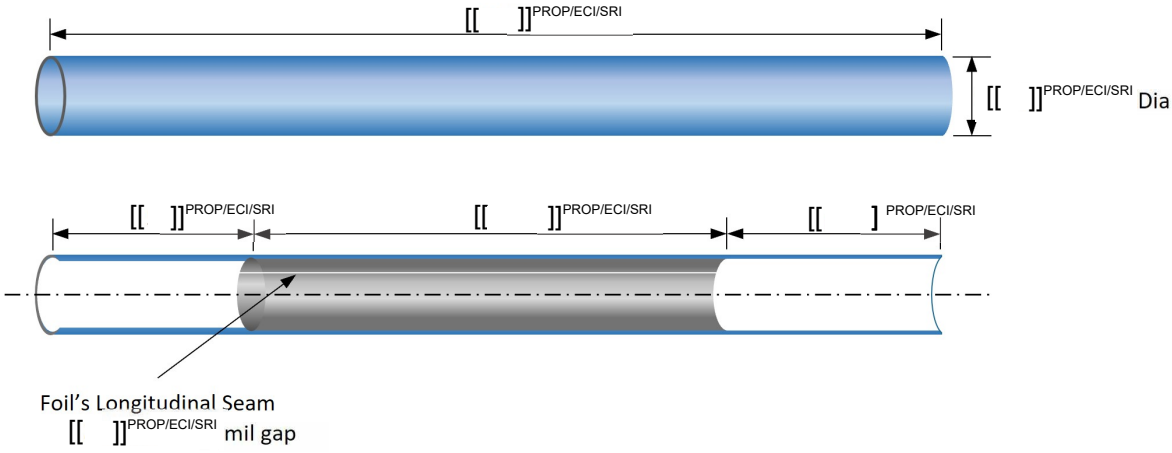

Figure 4b.4-9
Hydroforming Pressure Versus Time Plot

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Figure 4b.4-10
Axial Section of a Hydroformed Target

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Chapter 5
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Chapter 5a
Reactor Coolant Systems

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CHAPTER 5a
REACTOR COOLANT SYSTEMS

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Number	Title
5a.2-1	Primary Coolant System
5a.3-1	Secondary Coolant System

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
ASME	American Society of Mechanical Engineers
DC	design criteria
dP	differential pressure
gal.	gallon(s)
gpm	gallon(s) per minute
kg/s	kilogram(s) per second
L	liter(s)
MWt	megawatt-thermal
N-16	nitrogen-16
OCDS	operator control and display system
P&ID	piping and instrumentation diagram
RF	Reactor Facility
TX	Texas

5a Reactor Coolant Systems

5a.1 SUMMARY DESCRIPTION

Chapter 5a provides the design bases, system descriptions, and functional analysis of the reactor coolant and associated systems. The principal purpose of the nonsafety-related reactor coolant system is to remove heat from the reactor core with the reactor operating at full power and to remove decay heat from the reactor core with the reactor shutdown. The reactor coolant system is comprised of the primary and secondary coolant systems. The reactor pool is part of the primary coolant system. The reactor pool also provides neutron moderation for the core, provides radiation shielding for workers in the Reactor Facility (RF) high bay, and acts as a decontamination filter for any radionuclides released from target elements under accident conditions.

Systems associated with the reactor coolant system include the primary coolant cleanup system and the primary coolant makeup water system. Handling of solid and liquid waste is discussed in Chapter 11.

The reactor core is located in a large pool of water. Core fission and decay heat are transferred from the targets into the reactor pool water. Cooling water flows through the core via natural circulation driven by the temperature gradient across the core and chimney. Cooling water from the pool enters the bottom of the core through the downcomer, passes through the core, and is discharged back into the pool from the chimney. Chapter 4a provides a more detailed description of the natural circulation flow established by the differential water temperature in the downcomer, the reactor core and the chimney.

The open-pool reactor utilizes water as both the moderator and coolant. The reactor pool, described further in Section 4a.3, maintains a significant volume of highly pure, deionized water such that when the reactor is operating at full power, the pool heat-up rate is small. As described in Section 4a.3, the coolant system is not required to operate during reactor shutdown because the large volume of water in the pool results in no additional cooling requirements with the reactor shut down.

Pool cooling is accomplished by redundant heat exchangers external to the pool. Pool cooling is required to maintain the water temperature in the pool downcomer at temperatures within acceptable limitations. Table 5a.2-1 shows fuel element channel natural circulation flow rate and temperatures (inlet and outlet) based on a nominal 20 degrees Celsius (°C) (68 degrees Fahrenheit [°F]) channel inlet temperature. The primary coolant system is capable of sufficient heat removal to support continuous operation at full licensed power of the reactor.

The secondary coolant system cools the primary coolant system water and rejects the heat to the environment outside of the RF. Pumps are required on the secondary side of the coolant system to circulate the water. The make-up water source for the secondary side of the coolant system is from the municipal water utility service. The secondary side water passes through cooling towers located outside of the RF. The cooling towers are rated to maintain the desired outlet water temperature on the primary side of the heat exchangers. The water chemistry is maintained on the secondary side using a chemical addition system.

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5a.2 REACTOR PRIMARY COOLANT SYSTEM

5a.2.1 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The design basis for the reactor primary coolant system is as follows:

- The primary coolant system removes a minimum of 1.8 megawatts thermal (MWt) of heat from the pool water during full-power operation.
- The primary coolant system is not relied upon for decay heat removal with the reactor shut down.
- The primary coolant system maintains the primary side coolant at a lower pressure than the secondary side coolant such that any leakage in the heat exchanger is from the secondary side to the primary side.
- The inlets to the primary cooling pumps are located such that, in the event of a pipe break, pool level remains sufficiently above the core to maintain biological shielding and decay heat removal.
- The primary coolant system provides two independent cooling loops with a cross connection to provide the necessary redundancy such that no single reactor coolant system active component failure would prevent the reactor from operating at full power.
- The primary coolant system is located within the high bay to ensure that any planned or accidental releases of the primary coolant pool water are controlled and managed.
- The primary coolant system provides indication to the reactor operator regarding the primary coolant system operating conditions, including temperature, flow rate, and pressure.

The following design criteria (DC) apply to the design of this system.

- DC 6, Reactor Design: The design of the primary coolant system includes margin to ensure that target design limits are not exceeded during normal operation and anticipated operational occurrences.
- DC 9, Reactor Coolant Boundary: The primary coolant system design includes margin to ensure that design conditions of the pressure boundary are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 16, Heat Removal: The primary coolant system is designed to remove sufficient heat from the reactor to prevent target cladding failure during normal operation and anticipated operational occurrences.
- DC 19, Radioactive Material Control: The primary coolant system is designed to ensure adequate safety by maintaining the pressure boundary and providing heat removal during normal operation, anticipated operational occurrences, and accident conditions.

The primary coolant system is designed to the following relevant codes and standards:

- American Society of Mechanical Engineers (ASME) B31.1-2024, Power Piping, (ASME, 2024).
- ASME B16.34-2025, Valves — Flanged, Threaded, and Welding End, (ASME, 2025).

5a.2.2 SYSTEM DESCRIPTION

The concrete reactor pool structure and supporting base mat and transfer canal structure and base mat are safety-related and lined with nonsafety-related stainless steel. There are no piping penetrations in the pool structure or liner below the overflow level as shown on Figure 4a.2-4. All the primary coolant system piping is stainless steel. The primary coolant system is presented schematically in a primary coolant system piping and instrumentation diagram (P&ID), Figure 5a.2-1. Only the main components are depicted in the schematic.

The primary coolant system contains redundant pumps and heat exchangers with cross-ties not shown in the figure. The pumps provide the flow and pressure for the primary side of the cooling system. Only one pump is necessary for cooling during full power reactor operations. The primary coolant loops have a cross tie, allowing either pump or heat exchanger to be isolated. Additional isolation valves ensure that no active component is a single point of failure and allows either pump to supply either primary system cooling loop. Piping is configured such that a pipe failure cannot siphon water from the pool. A siphon break prevents siphoning effects within the reactor pool. The pump suction for the primary coolant pumps is located above the minimum reactor pool level required to maintain enough primary coolant level for biological shielding and decay heat removal in the event of primary coolant system piping rupture or component malfunction.

The two heat exchangers are each sized to remove a minimum of 1.8 MWt from the primary cooling system. Only one heat exchanger is necessary for heat removal at full power reactor operation.

Analysis of the primary coolant system water is performed periodically to ensure the water quality requirements are being maintained and that contaminants are not present in the system. Water quality, purity and radionuclide content are monitored and maintained by the primary coolant cleanup system and the primary coolant makeup water system.

The large volume of the pool, approximately 101,000 liters (L) (26,700 gallons [gal.]) of water, excluding the volume in the transfer canal (approximately 25,300 L [6700 gal.]), allows for a large thermal mass during both full-power operation and decay heat removal during shutdown. The pool heat-up rate without pool cooling at 1.8 MWt is 0.0043°C (0.0077°F) per second, 0.254°C (0.457°F) per minute, or 15.3°C (27.5°F) per hour. Assuming a core decay heat load of 35 kilowatts thermal (1.95 percent of full power at 10 minutes after reactor shutdown), the pool heat-up rate would be 0.3°C (0.54°F) per hour. Therefore, there is no requirement for the primary coolant system to operate during shutdown.

5a.2.3 INSTRUMENTATION AND CONTROLS

The transducers in the primary coolant system are integrated into the operator control and display system (OCDS) in the reactor control room and monitor the reactor pool water level bulk pool water temperature, pH, and resistivity. The primary coolant system flow rate, pressure, inlet temperature, and exit temperature listed in Table 5a.2-1 are also monitored. If the reactor pool water level, bulk pool water temperature, pH, resistivity, inlet or outlet temperatures, flow rate, or pressure are outside of the range of operating conditions, the OCDS provides the operator with warning and alarm indications. The OCDS is described in detail in Chapter 7a.

Table 5a.2-1
Key Design Parameters of the Primary Coolant System

Parameter	Value
Coolant medium	Light water
Coolant source	Primary coolant make-up water system
Primary coolant heat exchanger minimum heat removal capability	1.8 MWt
Fuel element coolant temperatures (nominal)	Inlet: 20˚C[(a)] Outlet: 46˚C[(a)]
Fuel element channel flow rate (nominal)	16.4 kg/s[(a)]
Primary coolant flow rate and temperatures	TBD[(a)(b)]
Primary coolant system material composition	Primarily stainless steel
Primary coolant system design pressure	Lower pressure than secondary side coolant

(a) Value to be determined based on final design calculations and documented in the Operating License Application.
(b) Primary coolant system flow rate and temperatures at the primary coolant heat exchanger are determined during detailed design based on maintaining fuel element coolant temperatures within acceptable limitations.

Abbreviations: MWt = megawatt-thermal | °C = degrees Celsius | kg/s = kilograms per second

5a.3 REACTOR SECONDARY COOLANT SYSTEM

5a.3.1 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The design basis for the reactor secondary coolant system is as follows:

- The secondary coolant system provides sufficient cooling capacity for the primary coolant system such that the returning primary coolant water is within acceptable temperature limits when the reactor is operating at full power.
- Water chemistry, level, and bleed-off in the secondary coolant system are controlled to control corrosion and biological growth and the plate out of minerals in the system.
- The secondary coolant system provides redundancy to ensure that no single reactor coolant system component failure can prevent the reactor from operating at full power.
- The secondary coolant system provides the reactor operator with secondary coolant system equipment status and operating conditions, including water temperatures, outside air temperature, outside air humidity (or wet bulb temperature), flow rate, and pressure.
- The secondary side is maintained at a higher pressure than the primary side such that any leakage in the heat exchanger is from the secondary side to the primary side.

The following DCs apply to the design of this system:

- DC 6, Reactor Design: The secondary coolant system design includes margin to ensure that target design limits are not exceeded during normal operation, including the effects of anticipated operational occurrences.
- DC 16, Heat Removal: The secondary coolant system is designed to remove sufficient heat from the primary coolant system to prevent target cladding failure during normal operation and anticipated operational occurrences.
- DC 19, Radioactive Material Control: The secondary coolant system design supports control of radioactive material by maintaining system pressure greater than primary coolant system pressure.

The secondary coolant system is designed to the following relevant codes and standards:

- ASME B31.1-2024, Power Piping, (ASME, 2024).
- ASME B16.34-2025, Valves — Flanged, Threaded, and Welding End, (ASME, 2025).

5a.3.2 SYSTEM DESCRIPTION

The secondary coolant system is presented schematically in the secondary coolant system P&ID, Figure 5a.3-1. The secondary coolant system contains redundant pumps and redundant cooling towers with cross-ties not shown in the figure. The pumps provide the flow and pressure for the secondary side of the cooling system. Only one pump is necessary for full power reactor operations.

The cooling towers are each capable of heat rejection to the atmosphere to maintain coolant temperatures within design parameters during all foreseeable environmental conditions. Only one cooling tower is necessary for full power reactor operations; each cooling tower is sized to reject at least 2 MWt. Water must be added to the secondary coolant system to replace water lost by evaporation in the cooling process, tower drift, and through periodic bleed-off.

The coolant water chemistry is maintained to prevent scaling and deposition, and corrosion or degradation of metal parts within the secondary coolant system. Water discharged from the secondary coolant system bleed-off is transferred directly to the evaporation pond.

The heat exchangers provide a robust boundary between the primary and secondary water coolant, and no radionuclides are expected to be present in the secondary coolant water. The only means for radionuclides from the primary system to enter the secondary system is through a leak in a heat exchanger and the failure of the secondary system to maintain a higher pressure. The OCDS monitors differential pressure (dP) between the primary and second sides of the coolant system. Table 5a.3-1 presents key design parameters for the secondary coolant system.

5a.3.3 INSTRUMENTATION AND CONTROLS

The transducers from the secondary coolant system are integrated into the OCDS in the reactor control room and monitor the water level in the cooling towers' reservoirs, the bulk water temperature, and its resistivity. The secondary coolant system flow rate or pressure, inlet temperature, and exit temperature are also monitored.

Table 5a.3-1
Key Design Parameters of the Secondary Coolant System

Parameter	Value
Coolant medium	Light water
Coolant make-up source	Municipal water system
Secondary coolant system design pressure	Higher pressure than primary side coolant
Secondary coolant medium	Light water
Secondary coolant temperature (approximate)	Inlet. 29˚C [(a)] Outlet: 35˚C [(a)]
Secondary coolant flow rate (approximate)	85.4 kg/s [(a)]
Tower water wet bulb (Midland, TX)	23˚C

(a) Value to be determined based on final design calculations and documented in the Operating License Application.

Abbreviations: °C = degrees Celsius | kg/s = kilograms per second | TX = Texas

5a.4 REACTOR PRIMARY COOLANT CLEANUP SYSTEM

5a.4.1 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The design basis for the reactor primary coolant cleanup system is as follows:

- The primary coolant cleanup system provides purity control to reduce fouling and degradation of fuel, core, and primary coolant system components.
- The primary coolant cleanup system provides the capability to remove radionuclides from the reactor pool water.

The following DCs apply to the design of this system:

- DC 9, Reactor Coolant Boundary: The cleanup system interfaces with the primary coolant system. The primary coolant cleanup system design includes margin to ensure that design conditions of the primary coolant system pressure boundary are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 15, Reactor Coolant Makeup and Cleanup Systems: The primary coolant cleanup system is designed to maintain the required cleanliness of the primary coolant system.
- DC 19, Radioactive Material Control: The primary coolant cleanup system design supports removal of radionuclides from the primary coolant system.

The primary coolant cleanup system is designed to the following relevant code:

- ASME B31.1-2024, Power Piping, (ASME, 2024).

5a.4.2 SYSTEM DESCRIPTION

The primary coolant cleanup system's main components include pumps, a pre-filter, demineralizer resin beds, and a post-filter. Except for the filters and resin beds, all the components are fabricated from stainless steel. Figure 5a.2-1 shows the cleanup system interface with the primary coolant system.

The system is designed to cycle approximately 10 percent of the pool water through the primary coolant cleanup system per hour. The demineralizer beds are sized appropriately to ensure flows can be accommodated by the resin beds to prevent capacity loss or early degradation of resin materials. The demineralizer resin beds are replaced periodically. The demineralizer tanks are reusable, and the resin bed can be removed and replaced.

The potential for corrosion of the reactor components is greatly minimized by controlling the conductivity in the pool water. In addition, any radioactive ions in the pool water are captured by the demineralizer bed, reducing the amount of radioactivity within the reactor pool.

5a.4.3 INSTRUMENTATION AND CONTROLS

The transducers in the primary coolant cleanup system are integrated into the ODCS in the reactor control room and monitor the primary coolant cleanup system dP across the

demineralizer, the flow rate, water temperature, pH, and resistivity. The OCDS is described in detail in Chapter 7a.

5a.5 REACTOR PRIMARY COOLANT MAKEUP WATER SYSTEM

5a.5.1 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The design basis for the reactor primary coolant makeup water system is to provide highly pure makeup water to the primary coolant system.

The following DC applies to the design of this system:

- DC 15, Reactor Coolant Makeup and Cleanup Systems: The reactor primary coolant makeup water system maintains pool inventory.

The primary coolant makeup system is designed to the following relevant code:

- ASME B31.1-2024, Power Piping, (ASME, 2024).

5a.5.2 SYSTEM DESCRIPTION

The primary coolant makeup water system is designed to operate when needed to maintain the pool at the appropriate operating level range. All the components within the make-up water system are fabricated from stainless steel, with the exception of the demineralizer beds.

The makeup water is from the municipal water utility service, which is subsequently filtered and deionized. A demineralizer is used to deionize the water as it is added to the system. The makeup water system interface with the primary coolant cleanup system is shown on Figure 5a.2-1. A reduced pressure backflow prevention device and solenoid valves are also part of the system and allow for protection of the makeup water source from a possible cross connection with a non-potable water source.

The demineralizer beds are sized appropriately to ensure the necessary water flow can be accommodated without capacity loss or early degradation of the resin.

5a.5.3 INSTRUMENTATION AND CONTROLS

Transducers used to monitor the primary coolant makeup water system are integrated into the OCDS in the reactor control room. If the reactor pool water level exceeds the filled level, an overflow drain transfers the excess water by gravity feed to a below floor level collection well in the reactor cooling system room. A level sensor in the collection well, through an interlock function to the makeup water system, prevents water addition to the pool if the water level in the collection well is at or above a prescribed level. The OCDS is described in detail in Chapter 7a.

5a.6 NITROGEN-16 CONTROL SYSTEM

As described in Chapter 4a, nitrogen-16 (N-16) is created in the pool water in the reactor core region primarily by the (n,p) reaction with oxygen-16. Chapter 4a describes the saturated activity for the N-16 in the pool with the reactor operating at full power. At full power reactor operation (1.8 MWt) radiation levels on the reactor bridge structure directly above the reactor are less than 10 millirem/hr from direct radiation and N-16 decay. An N-16 control system is therefore not included in the design basis for the RF.

5a.7 AUXILIARY SYSTEMS USING PRIMARY COOLANT

There are no auxiliary systems that use primary water for cooling or for other purposes. Auxiliary systems using primary coolant are not included in the design. Therefore, this section does not apply.

5a.8 TESTING AND INSPECTION

Descriptions of any tests and inspections of the reactor coolant system will be provided with the application for the Operating License.

5a.9 POTENTIAL TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

5a.10 REFERENCES

ASME, 2024. Power Piping, ASME B31.10.2, American Society of Mechanical Engineers, 2024.

ASME, 2025. Valves – Flanged, Threaded, and Welding End, ASME B16.34, American Society of Mechanical Engineers, 2025.

Figure 5a.2-1
Primary Coolant System

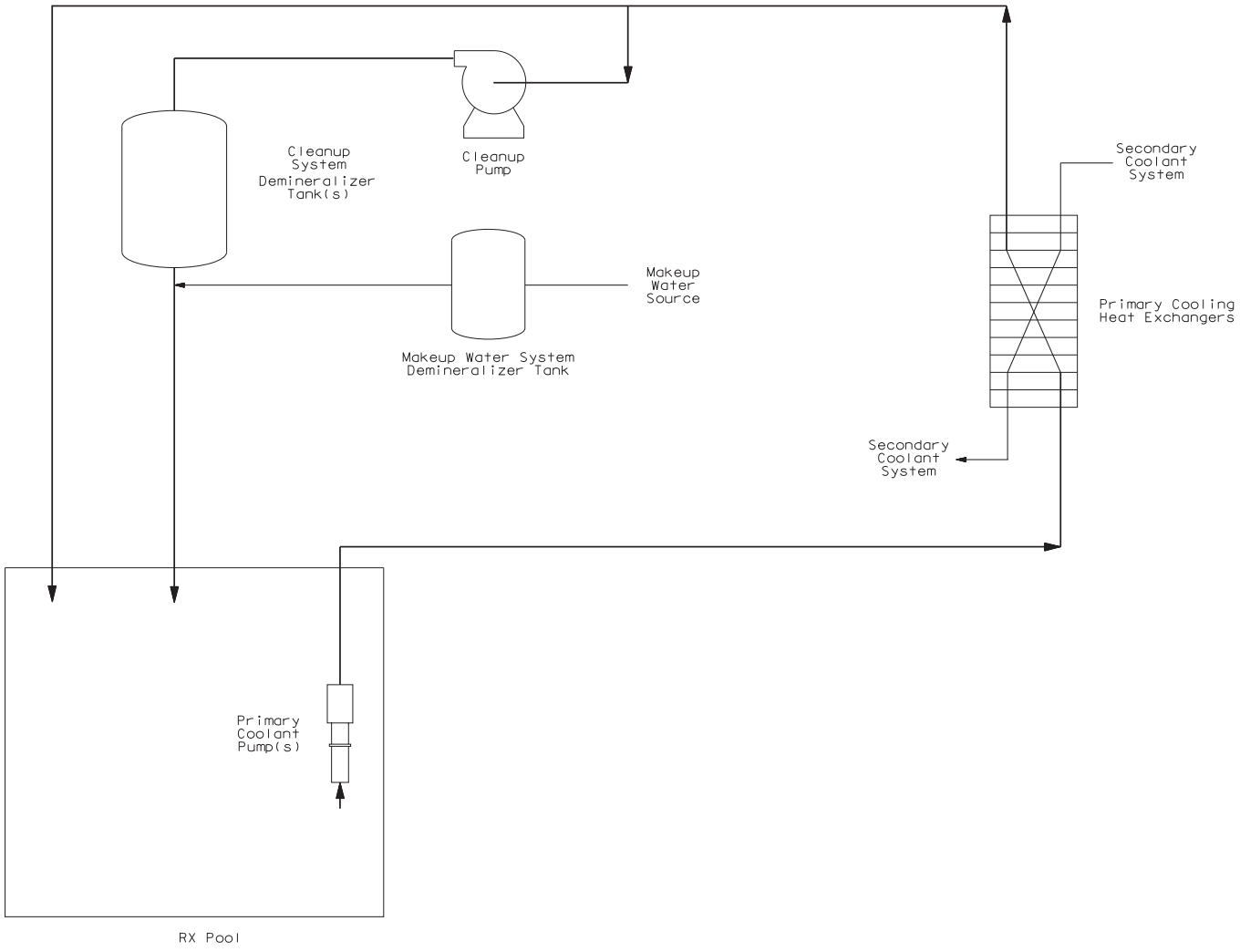
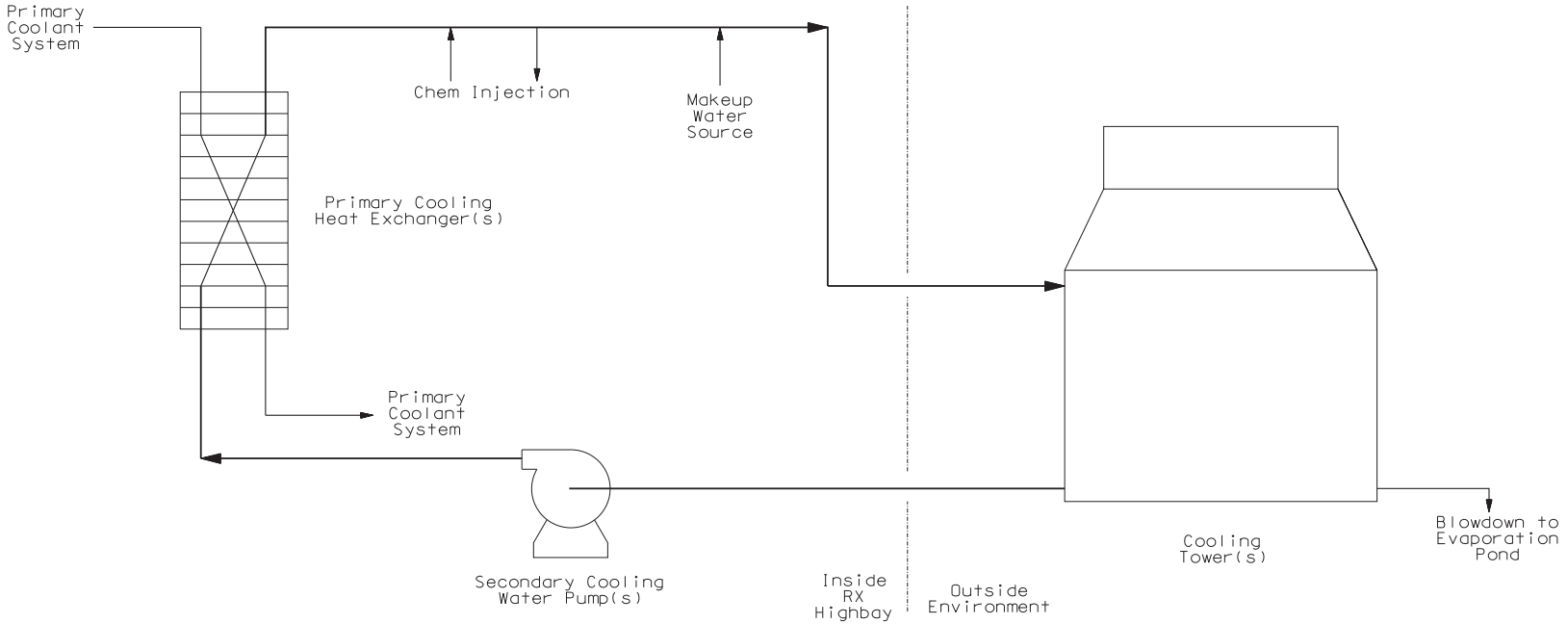


Figure 5a.3-1
Secondary Coolant System



Eden Isotope Production Complex
Preliminary Safety Analysis Report

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Chapter 5b
Radioisotope Production Facility Cooling Systems

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CHAPTER 5b

RADIOISOTOPE PRODUCTION FACILITY COOLING SYSTEMS

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5b.2-1	Target Temperature in Air – 30 kW for 25-Day Burnup

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
β	beta particle
ΔT	differential temperature
γ	gamma ray
°C	degrees Celsius
°F	degrees Fahrenheit
Cu	copper
DC	design criterion(a)
FGDS	fission gas delay system
g	gram(s)
gal.	gallon(s)
HCF	Hot Cell Facility
kW	kilowatt(s)
kWt	kilowatt thermal
L	liter(s)
LET	linear energy transfer
LEU	low-enriched uranium
LLW	low-level waste
Mo-99	molybdenum-99
SCB	steel confinement box
SSC	structure(s), system(s), and component(s)
U	uranium
UREX	uranium extraction
W	watt(s)

5b Radioisotope Production Facility Cooling Systems

At full power the low-enriched uranium (LEU) targets in the all-target reactor core operate at an average power level of 30 kilowatts thermal (kWt) up to a maximum burnup level of 0.75 megawatt days. After irradiation, targets are transferred underwater in the transfer canal to the Hot Cell Facility (HCF) target processing canyon. The fission produced radioisotopes, in particular molybdenum-99 (Mo-99), iodine-131, and xenon-133, are separated from the irradiated LEU and the other fission products and purified for acceptable use by the customer. This is performed by dissolving the irradiated uranium (U) from up to six targets in a nitric acid bath in a dissolver unit within one of the four designated steel confinement boxes (SCBs) and performing several chemical steps to separate and purify the desired radioisotopes. The remaining U, fission product, and actinide solution are transferred to other SCBs for separation of the LEU as a solid oxide using a U extraction (UREX) process and solidification of the fission product and actinide solution into a concrete grout for future disposal at a low-level waste (LLW) site as Class C waste.

During irradiated target handling, LEU foil separation from the cladding, LEU foil dissolution, UREX process, and waste handling, the fission products decay by beta and gamma-ray emission, resulting in heat being generated in the intrinsic material associated with the fission products. The processing hardware is designed and operated with the heat load requirements integrated into the design and operation of the system. For beta emission, it is assumed that all the energy is deposited locally in the intrinsic material because the linear energy transfer (LET) is large. For gamma-ray emission, some of the energy escapes the intrinsic material because the LET is small.

The cooling requirements for the system associated with each of the activities in the SCBs are dependent on the activity and the fission product inventory and time duration for the activity. Some activities only require natural convection air cooling, while others require nitrogen cooling or a water bath.

The following sections identify the preliminary heat generation and cooling requirements for each process activity and the expected fission product heat load. Because the systems associated with the processing activities are currently under development, a complete description of the systems and the cooling requirements will be provided in the Operating License Application. This description will include the design bases, physical characteristics, final design, and planned operation of the system.

The following design criteria (DC) apply to the process cooling activities:

- DC 18, Control of Releases of Radioactive Materials to the Environment: Production and support structures, systems, and components (SSCs) that store, handle, or process radioactive materials, or radioactive waste, produced during normal production operation, anticipated operational occurrences, and accident conditions are designed to ensure control of environmental releases in gaseous and volatile forms. This includes providing holdup capacity, as necessary, for retention of radioactive gases.
- DC 19, Radioactive Material Control: Production and support SSCs that store, handle, or process radioactive materials, or radioactive waste, are designed to ensure adequate control of the material under normal operation, anticipated operational occurrences, and accident conditions. Provisions for detection of excessive radioactive levels and

appropriate safety actions are provided. The design includes the capability to permit required inspection and testing.

5b.1 FISSION PRODUCT INVENTORY HEAT GENERATION

Fission product inventory heat generation is calculated using the fission product inventory from ORIGEN-2.2 calculations and the average beta particle and gamma-ray disintegration energy for each fission product isotope (Browne & Firestone, 1986). The ORIGEN case is for an average target power of 30 kWt irradiated for 25 days. Selected decay times are for 4 hours, 6 hours, 8 hours, 10 hours, 20 hours, 7 days, 4 months, and 1 year, representing the complete time spectrum from removal of the target from the reactor through waste disposal.

Table 5b.1-1 presents the results for heat generation, with radioisotope fission products grouped as Mo-99, noble gases, halogens, and the remaining fission products. At 4 months and beyond, the heat generation is dominated by the isotopes strontium-89, yttrium-91, zirconium-95, niobium-95, ruthenium-103, and praseodymium-144.

Table 5b.1-1
Fission Product Heat Generation per Target from Beta and Gamma-Ray Emission – 30 kW for 25-Days of Burnup

Decay Time	Heat Rate (watts)			
	Mo-99	**Nobles**	**Halogens**	**Remaining Fission Products**
4 hours	[[	[[	[[	[[
6 hours				
8 hours				
10 hours				
20 hours				
7 days				
4 months				
1 year	]]PROP/ECI	]]PROP/ECI	]]PROP/ECI	]]PROP/ECI

Abbreviations: kW = kilowatt(s) | Mo-99 = molybdenum-99 | β = beta particle | γ = gamma ray

5b.2 ACTIVITY SPECIFIC FISSION PRODUCT HEAT GENERATION

The main activities associated with fission product heat generation in the HCF target processing canyon are the following:

- Irradiated target ready for cladding removal in air.
- Irradiated foil ready for dissolution in air.
- Multiple foils dissolved in nitric acid.
- Separation of nobles, halogens, and fission product solution.
- Separation of Mo-99 from fission product solution.
- Fission product solution transfer to UREX box.
- UREX processing and separation of LEU.
- Fission product solution conversion to solid grout LLW.
- Waste storage.

The heat generation and cooling requirements for the processing systems for each of these activities are presented in the following subsections.

5b.2.1 IRRADIATED TARGET IN AIR

Irradiated targets are moved underwater to the HCF target processing canyon via the transfer canal. The targets are allowed to decay in the transfer canal for a period of at least 4 hours before processing to ensure that the short-lived tellurium isotopes have decayed to iodine. The actual decay time is greater than 4 hours and could be as long as 20 hours. However, for conservative analysis, a 4-hour decay period is assumed.

After 4 hours, the irradiated target transfer basket is raised into the target receipt box, the targets are removed from the basket (from water to air), inspected, and identified as the correct ones to be processed. The target flutes are removed and the targets parsed into batches of up to six and transferred to one of four dissolver boxes.

From the time a target enters the target receipt box until it is prepared for dissolution, it is passively cooled by natural circulation of the air within the SCB. Assuming all the beta energy and a Monte Carlo N-Particle Transport program calculated fraction of the gamma energy are deposited into the fuel and cladding, the target temperature is calculated assuming an air natural convection heat transfer coefficient and an axial peaking factor of 1.25.

After 4 hours of decay, as shown in Table 5b.2-1, the target temperature is calculated to be [[ ]]PROP/ECI degrees Celsius (°C) to [[ ]]PROP/ECI hotter than the ambient temperature of the air (20°C [68°F]). The target temperature is less for a 6-hour decay [[ ]]PROP/ECI.

5b.2.2 IRRADIATED FOIL IN AIR

After an irradiated target is moved into the dissolver box, it is prepared for dissolution by separating the LEU foil from the cladding. A mechanical parting wheel is used to cut the outer aluminum cladding tube. The LEU foil is removed and placed in the dissolution unit. The heating of the LEU foil is similar to that of a target in air, and the temperatures of the foil are similar. The LEU foil is coated with nickel, precluding U oxidation.

5b.2.3 MULTIPLE FOILS DISSOLVED IN NITRIC ACID

Up to six irradiated LEU foils can be dissolved at one time within a dissolver unit in a dissolver box. The dissolver unit is described in Subsection 4b.3.2. U metal dissolution in nitric acid is an exothermic process, with [[ ]]$^{PROP/ECI}$ kilojoule/grams (g)-mole U given off as heat. The dissolution process is expected to take 2 hours to complete. Six LEU foils have a mass of [[ ]]$^{PROP/ECI/SRI}$ g of U, or about [[ ]]$^{PROP/ECI}$ g-moles. During the 2-hour dissolution period, the heating from the chemical reaction is about 623 watts (W). After 4 hours of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. After 6 hours of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. The total heat rate, including the exothermic chemical reaction, is about [[ ]]$^{PROP/ECI}$ kilowatts (kW) after 4 hours of decay and [[ ]]$^{PROP/ECI}$ kW after 6 hours of decay. During the U metal foil dissolution, the dissolver unit is cooled externally by a water bath and internally by a nitrogen gas cooling coil.

5b.2.4 SEPARATION OF NOBLES, HALOGENS, AND FISSION PRODUCT SOLUTION

After the LEU foils are dissolved in the nitric acid in a dissolver unit, the noble gases and halogens are evacuated from the unit using the fission gas delay system (FGDS), described in Subsection 4b.3.3. Liquid nitrogen is used to cryogenically cool a sorption pump that evacuates the dissolver unit through an iodine trap that is filled with copper (Cu) shavings and is at room temperature. The halogens (iodine) are chemically absorbed by the Cu shavings, and the noble gases are trapped within the cryogenically cooled sorption pump. After evacuation of the dissolver unit is completed, the FGDS is valved-off from the dissolver unit. The iodine trap is valved-off from the cryogenically cooled vessel. The vessel is allowed to warm to room temperature.

The dissolver unit evacuation is performed immediately after the dissolution process is completed. After 6 hours of decay, the beta heating in the noble gas sorption pump is [[ ]]$^{PROP/ECI}$ W for six targets of noble gas inventory. The beta heating in the iodine trap is [[ ]]$^{PROP/ECI}$ W for six targets of iodine inventory. After a 7-day decay period, the beta heating in the noble gas sorption pump is [[ ]]$^{PROP/ECI}$ W for six targets of noble gas inventory. The beta heating in the iodine trap is [[ ]]$^{PROP/ECI}$ W for six targets of iodine inventory. The sorption pump and iodine trap are cooled externally by natural convection cooling from the air in the dissolver box.

5b.2.5 SEPARATION OF MO-99 FROM THE FISSION PRODUCT SOLUTION

After the dissolver unit is evacuated, the fission product solution is passed through a titania column to remove the Mo-99 for later purification using the modified Cintichem process. After 8 hours of decay, the beta heating in the titania column from the Mo-99 is [[ ]]$^{PROP/ECI}$ W for six

targets of inventory. The remainder of the fission product solution is staged in a transfer vessel for decay and later transfer to the UREX box for separation of the LEU in oxide form from the solution.

After 8 hours of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. After 7 days of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. The total heat rate for the fission product solution is [[ ]]$^{PROP/ECI}$ W after 8 hours of decay and [[ ]]$^{PROP/ECI}$ W after 7 days of decay. The transfer vessel is cooled by natural convection using air or a water bath.

5b.2.6 FISSION PRODUCT SOLUTION TRANSFER TO UREX BOX

After a 7-day decay period, the fission product solution is transferred to the UREX box for separation of the LEU from the raffinate solution. At 7 days of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. The total heat rate is [[ ]]$^{PROP/ECI}$ W after 7 days of decay.

5b.2.7 UREX PROCESSING AND SEPARATION OF LEU

The LEU, in the form of uranyl nitrate, is separated from the fission product solution using the UREX process. The raffinate solution (the fission product and actinide solution minus the U) is transferred to the waste packaging box for solidification. At 7 days of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for six targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for six targets, assuming a gamma-ray energy absorption factor of 0.4. The total heat rate is [[ ]]$^{PROP/ECI}$ W after 7 days of decay. The UREX hardware is cooled by natural convection cooling in air.

5b.2.8 FISSION PRODUCT SOLUTION CONVERSION TO SOLID GROUT LOW-LEVEL WASTE

The raffinate solution is mixed with other liquid waste from the processing activities and grouted using Portland cement and sand in a 55-gallon (gal.) (208-liter [L]) drum. It is assumed that up to 12 targets of raffinate solution can be grouted in a 55-gal. (208-L) waste drum. After 7 days of decay, the beta heat rate in the solution is [[ ]]$^{PROP/ECI}$ W for 12 targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for 12 targets, assuming a gamma-ray energy absorption factor of 1.0. The total heat rate is [[ ]]$^{PROP/ECI}$ W after 7 days of decay for 12 targets of fission product inventory.

5b.2.9 WASTE STORAGE

The waste drums are stored in the waste storage canyon for a period of 4 months or longer. After 4 months of decay, the beta heat rate in a waste drum is [[ ]]$^{PROP/ECI}$ W for 12 targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for 12 targets, assuming a gamma-ray energy absorption factor of 1.0. The total heat rate is [[ ]]$^{PROP/ECI}$ W after 4 months of decay for 12 targets of fission product inventory.

After one year of decay, the beta heat rate in a waste drum is [[ ]]$^{PROP/ECI}$ W for 12 targets. The gamma-ray heat rate is [[ ]]$^{PROP/ECI}$ W for 12 targets, assuming a gamma-ray energy absorption

factor of 1.0. The total heat rate is [[ ]]$^{PROP/ECI}$ W after one year of decay for 12 targets of fission product inventory.

The 55-gal. (208-L) waste drums are cooled by natural convection in the waste storage canyon.

Table 5b.2-1
Target Temperature in Air – 30 kW for 25-Day Burnup

Decay Time	Heat Rate (watts)	Gamma Fraction Absorption	ΔT (°C) with emissivity	ΔT (°C) without emissivity
4 hours	[[	[[	[[	[[
6 hours				
20 hours	]]PROP/ECI	]]PROP/ECI	]]PROP/ECI	]]PROP/ECI

Abbreviations: kW = kilowatt(s) | °C = degrees Celsius | ΔT = differential temperature | β = beta particle | γ = gamma ray

5b.3 SUMMARY AND CONCLUSIONS

Cooling requirements for the SSCs associated with the HCF Mo-99 production activities have been analyzed. Fission product inventory and associated heating rates were applied in establishing cooling requirements for production activities which include irradiated target handling and preparation, irradiated foil dissolution, separation of nobles and halogens from the fission product solution, separation of Mo-99 from the fission product solution, UREX processing and separation of LEU, fission product solution conversion to solid grout, and waste storage.

Final design details will be provided in the Operating License Application.

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

5b.4 REFERENCES

Browne, E., and R.R. Firestone, 1986. Table of Radioactive Isotopes, John Wiley and Sons, Inc., 1986.

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Chapter 6
Engineered Safety Features

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Chapter 6a
Reactor Facility Engineered Safety Features

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CHAPTER 6a
REACTOR FACILITY ENGINEERED SAFETY FEATURES

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None.

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ACI	American Concrete Institute
ALARA	As Low As Reasonably Achievable
DC	design criterion(a)
EMIF	Eden Medical Isotope Facility
ESF	Engineered Safety Features
HCF	Hot Cell Facility
MHA	maximum hypothetical accident
RF	Reactor Facility
SSC	structure(s), system(s), and component(s)

6a. Reactor Facility Engineered Safety Features

6a.1 SUMMARY DESCRIPTION

Engineered Safety Features (ESFs) are passive or active features designed to mitigate the consequences of postulated events to keep radiological exposures to the public, workers, and the environment within acceptable values. This section describes the ESFs within the Reactor Facility (RF) that are designed to mitigate the consequences of postulated events, ensuring that any potential dose consequences are within acceptable values.

As described in Section 3.5, the Eden Isotope Production Complex contains safety-related and nonsafety-related buildings. These buildings include areas for the use and storage of licensed materials, ancillary spaces, site access control, and administrative offices. The Eden Medical Isotope Facility (EMIF) is the nuclear facility and contains the safety-related structures, systems, and components (SSCs) on the site. The safety-related areas within the EMIF are located in the RF and the Hot Cell Facility (HCF). The safety-related portions of the HCF are described in Chapter 6b.

The safety-related structural portions of the RF consist of the reactor pool structure and base mat concrete and the transfer canal structure and base mat concrete. A schematic of the EMIF structure that identifies both the safety-related and nonsafety-related portions is presented in Figure 3.5-1.

Fission product release accident scenarios for the reactor are described in Chapter 13a. A summary of the accident dose consequences in Chapter 13a is presented in Table 13a.3-1. The maximum hypothetical accident (MHA), which bounds all fission product release accident dose consequences, is a complete melt of the target with the highest power peaking factors irradiated for 25 days at 30 kilowatts thermal. Fission products are dispersed in the pool with some fission products escaping to the RF high bay. The MHA dose calculation assumes a ground level release and does not rely on the RF high bay ventilation system to operate or the RF high bay structure to delay a release to the environment. The resultant dose to a member of the public at the site boundary, or a dose to a worker in the RF who evacuates the RF, remain below regulatory limits.

The pool water is credited for fission product retention after the postulated MHA. Therefore, the pool water plays a vital role in reducing the dose consequences. As described in Chapter 3, the concrete reactor pool structure and base mat and the concrete transfer canal structure and base mat (Figure 3.5-1) are safety-related SSCs that ensure the integrity of the reactor pool and transfer canal.

The concrete reactor pool structure and base mat and the concrete transfer canal structure and base mat perform a passive design feature that mitigate the consequences of postulated events to keep radiological exposures to the public, workers, and the environment below regulatory limits. Consistent with this function, these safety-related SSCs are ESFs.

The RF does not utilize a containment or an emergency core cooling system.

6a.2 CONFINEMENT

The RF confinement consists of the RF high bay structure (see Figure 3.5-1) combined with the RF high bay ventilation system but is not credited or required for accident mitigative purposes. Therefore, it is not designated as an ESF. It provides defense-in-depth and serves to maintain doses As Low As Reasonably Achievable (ALARA).

Refer to Chapter 9a for a description of the RF high bay ventilation system.

6a.2.1 REACTOR POOL AND TRANSFER CANAL

The reactor pool and transfer canal are in-ground structures that contain the reactor water primary coolant. The reactor pool and transfer canal are described in Chapter 4a. The RF high bay, reactor pool, core, and transfer canal are shown in Figure 4a.2-3. The reactor pool is in the central area in the RF high bay. The layout of the reactor, pool cooling lines, and transfer canal is shown in Figures 4a.3-1 and 4a.3-2. The reactor pool and transfer canal consist of concrete base mats and walls with a stainless-steel liner. The reactor pool concrete structure and transfer canal concrete structure and their base mats are safety-related and are designated ESFs. The pool liner is not safety-related or an ESF.

The passive structures of the reactor pool and transfer canal establish the boundary and support for the water credited for fission product (excluding noble gases) retention after a fission product release accident. Fission product retention in the pool water is an important assumption of the accident analysis in Chapter 13a for certain fission product release accidents, including the MHA, because it limits the source term available for release to the environment and results in doses to members of the public at the site boundary that are within acceptable limits. Designating these structures as safety-related and ESFs supports the MHA assumption that fission products are released into the pool water rather than directly into the RF confinement atmosphere.

Major structural elements of these ESFs include the reinforced concrete pool and transfer canal foundation base mat and reinforced concrete pool and transfer canal walls. The foundation for the safety-related structures is below-grade mat slabs. The safety-related wall structures are wall systems mainly constructed of reinforced concrete. The transfer canal has a nonsafety-related cover to exclude foreign material from entering the canal.

These safety-related structures are subject to the Quality Assurance Program described in Section 12.9. These structures are designed to the structural loading based on the local building code, which adopts the requirements of the International Building Code (ICC, 2021), and augmented for specific design basis natural phenomena, such as extreme wind, flooding, and earthquake, as described in Section 3.5. These safety-related reinforced concrete structures are designed in accordance with the applicable load combinations from Section 9.2.1 of American Concrete Institute (ACI) document ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures (ACI, 2014).

These ESFs have no probable subjects for technical specifications.

6a.2.2 COMPLIANCE WITH DESIGN CRITERIA

The following design criteria (DC) apply to the design of the safety-related areas of the RF building structure (i.e., the concrete reactor pool structure and supporting base mat, and the transfer canal structure and supporting base mat):

- DC 5, Sharing of Structures, Systems, and Components: The transfer canal structure is shared between the RF and HCF. This is a passive structure, and sharing does not impair the ability of the RF or HCF to perform their safety functions.
- DC 9, Reactor Coolant Boundary: The safety-related areas of the RF building structure are designed to maintain the reactor pool water inventory. The structural design includes sufficient margin to ensure the design conditions are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 16, Heat Removal: The safety-related areas of the RF building structure are designed to maintain the reactor pool water inventory to provide heat removal from the reactor core.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The safety-related areas of the RF building structure are designed to maintain the reactor pool water inventory during normal operation, anticipated operational occurrences, and accident conditions. The reactor pool water inventory reduces the possible release of fission products to the RF high bay.
- DC 22, Inspection, Testing, and Maintenance: The safety-related areas of the RF building structure are designed, as appropriate, for adequate inspection, testing, and maintenance to ensure the availability and reliability to maintain the reactor pool water level.
- DC 23, Biological Shielding: The safety-related areas of the RF building structure are designed to maintain the reactor pool water level. The reactor pool water level provides shielding to protect the workers from unacceptable levels of radiation during normal operation, anticipated operational occurrence, and accident conditions.

6a.3 CONTAINMENT

The RF does not require a containment.

6a.4 EMERGENCY CORE COOLING SYSTEM

The RF does not require an emergency core cooling system. As described in the safety analysis presented in Chapter 13a, the reactor coolant inventory in the pool is sufficient to remove the decay heat from the core after shutdown. No emergency core cooling system is required to mitigate the consequences of a postulated event.

6a.5 REACTOR FACILITY ENGINEERED SAFETY FEATURES TECHNICAL SPECIFICATIONS

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

6a.6 REFERENCES

ACI, 2014. Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-13) and Commentary, ACI 349-13, American Concrete Institute, 2014.

ICC, 2021. International Building Code, IBC-2021, International Code Council, 2021.

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Chapter 6b
Hot Cell Facility Engineered Safety Features

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CHAPTER 6b
HOT CELL FACILITY ENGINEERED SAFETY FEATURES

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None.

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ANSI	American National Standards Institute
ANS	American Nuclear Society
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
CAAS	criticality accident alarm system
CFR	Code of Federal Regulations
CSE	Criticality Safety Evaluation
DC	design criterion(a)
EMIF	Eden Medical Isotope Facility
ESF	Engineered Safety Features
g	gram(s)
HCF	Hot Cell Facility
HEPA	high efficiency particulate air filter
ISA	Integrated Safety Analysis
k_{eff}	effective neutron multiplication factor
kg	kilogram(s)
lb.	pound(s)
LEU	low-enriched uranium
Mo-99	molybdenum-99
NCS	nuclear criticality safety
NCSP	Nuclear Criticality Safety Program
Ni	nickel
RF	Reactor Facility

Acronym/Abbreviation	Definition
SCB	steel confinement box
SNM	special nuclear material
SSC	structure(s), system(s), and component(s)
U	uranium
U-235	uranium-235
U_3O_8	uranium oxide
UO_2	uranium dioxide
UPSS	uninterruptible power supply system
UREX	uranium extraction

6b. Hot Cell Facility Engineered Safety Features

6b.1 SUMMARY DESCRIPTION

This section describes the Engineered Safety Features (ESFs) within the Hot Cell Facility (HCF) that are designed to mitigate the consequences of postulated events, ensuring that any potential dose consequences are within acceptable limits.

The HCF portion of the Eden Medical Isotope Facility (EMIF) is the production facility where isotopes are extracted from the irradiated targets. The HCF operates independently of the Reactor Facility (RF) with some common structures, systems, and components (SSCs), including the transfer canal, a wall separating the facilities, some common utilities, and monitoring (HCF functions are monitored in the reactor control room). The HCF has two ventilation systems and exhaust stacks for maintaining the atmosphere within the HCF and the HCF target processing canyon.

Fission product release accident scenarios and dose consequences within the HCF are described in Chapter 13b.

HCF confinement is required during the dissolution process to ensure that if an accident does occur within the dissolver box during the dissolution process, the nobles, halogens, and other volatile fission products are exhausted through the high efficiency particulate air (HEPA) and charcoal filters in HCF Zone 1a. Therefore, as described in Chapter 13b, ESFs credited for mitigation of postulated events within the HCF are steel confinement boxes (SCB) 2 through 7 and the HCF Zone 1a ventilation system (including fans, filters, dampers, ductwork, power supply, and instrumentation and controls).

No other ESFs are identified within the HCF from the accident analyses in Chapter 13b that would be required to mitigate the consequences of postulated events and to keep radiological exposures to the public, workers, and the environment within acceptable limits.

The HCF does not utilize a containment or an emergency cooling system.

6b.2 CONFINEMENT

6b.2.1 INTRODUCTION

The HCF confinement is the HCF ventilation system and associated structures that make up the system boundaries. Portions of the HCF ventilation system consists of safety-related/ESF and nonsafety-related ventilation systems as shown in Figure 9b.1-1. The nonsafety-related system description and requirements are provided in Chapter 9b.

The HCF Zone 1a ventilation system is an ESF. Associated supporting safety-related SSCs include system boundaries, uninterruptible power supply system (UPSS) (described in Chapter 8), and ventilation instrumentation. The HCF Zone 1a is a once-through ventilation system consisting of fans, ductwork, dampers, and filtration and receives transfer air from HCF Zone 2. The HCF Zone 1a ventilation system contains two redundant filter trains and exhaust fans to control the flow and maintain a negative pressure in HCF Zone 1a. The exhaust air from HCF Zone 1a is directed to its associated HCF Zone 1a exhaust stack.

The following design criteria (DC) apply to the design of the safety-related areas of the HCF building structure (i.e., the concrete waste storage canyon structure and supporting base mat, the transfer canal structure and supporting base mat, the target processing canyon, canyon shield doors, and the structure housing the HCF Zone 1a ventilation system):

- DC 5, Sharing of Structures, Systems, and Components: The transfer canal structure is shared between the HCF and RF. This is a passive structure, and sharing does not significantly impair the ability of the HCF or RF to perform their safety functions.
- DC 10, Confinement: The safety-related areas of the HCF structure are designed to provide a low-leakage barrier against uncontrolled releases of radioactivity to the rest of the facility and the environment, and to ensure that the released effluent from the HCF is filtered and discharged through the HCF exhaust stacks.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The safety-related areas of the HCF structure are designed to provide a low-leakage barrier to ensure that the release of gaseous effluents is controlled during normal operations, anticipated operational occurrences, and accident conditions.
- DC 22, Inspection, Testing, and Maintenance: The safety-related areas of the HCF building structure are designed, as appropriate, for adequate inspection, testing, and maintenance to ensure the availability and reliability to maintain the required safety function.
- DC 23, Structural Design for Biological Shielding: Shielding is provided to protect workers from unacceptable levels of radiation during normal operation, anticipated operational occurrences, and accident conditions. The structural features of the HCF that perform or support biological shielding to maintain off-site and worker doses below regulatory limits are safety-related. Structures surrounding or adjacent to biological shielding structural features may be nonsafety-related.

The following DC apply to the design of the SCBs 2 through 7:

- DC 10, Confinement: The SCBs are designed to provide a low-leakage barrier against uncontrolled releases of radioactivity to the rest of the facility and the environment and to

ensure that the released effluent is filtered and discharged through the HCF exhaust stacks.

- DC 17, Chemical Protection: The design of the SCBs provides for adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.
- DC 20, Criticality Control: The major criticality controlling parameters used in the HCF are geometry control and/or limitations on the mass of special nuclear material (SNM). Controls are described in detail in Section 6b.5.
- DC 22, Inspection, Testing, and Maintenance: The design for SCBs 2 through 7 includes provisions for inspection, testing, and maintenance to ensure availability and reliability to perform the credited functions.

The following subsection describes the confinement systems for HCF Zone 1a.

6b.2.2 CONFINEMENT SYSTEM AND COMPONENTS

As shown in Figure 9b.1-1, HCF Zone 1a is located within HCF Zone 2 and the mechanical equipment room. SCBs 2 through 7 are within the HCF Zone 1a boundary. As shown on Figure 9b.1-2, the HCF Zone 1a ventilation system maintains a negative pressure relative to HCF Zone 2 and HCF Zone 1b.

The HCF Zone 1a ventilation system consists of two 100 percent redundant trains of exhaust fans, dampers, filter banks located in the HCF mechanical equipment room. HCF Zone 1a is designed to local building codes and the following relevant codes and standards:

- American Society of Mechanical Engineers (ASME) AG-1, Code on Nuclear Air and Gas Treatment (ASME, 2023).
- American National Standards Institute (ANSI)/ American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 62.1-2022, Ventilation and Acceptable Indoor Air Quality (ANSI/ASHRAE, 2022).
- ASHRAE 90.1-2022, Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition (ASHRAE, 2022).
- ANSI/ASME N509-2002, Nuclear Power Plant Air-Cleaning Units and Components (R2008) (ANSI/ASME, 2008).
- ANSI/ASME N510-2007, Testing of Nuclear Air Treatment Systems (ANSI/ASME, 2007).

<u>Exhaust Fans & Dampers</u>

Two 100 percent exhaust fans are controlled using variable frequency drives. Instrumentation to monitor the differential pressure between HCF Zone 1a and HCF Zone 2 controls HCF Zone 1a fan speed to maintain HCF Zone 1a confinement.

Motor operated dampers are provided at the supply and discharge of each HCF Zone 1a exhaust fan.

Filtration

Two 100 percent filter banks are provided, each consisting of a pre-filter, a HEPA filter, and a charcoal filter. Within an individual filtration bank, the release of halogens and other nuclides to acceptable levels is achieved by use of the charcoal filtration and HEPA filtration. No filtering is assumed for noble gases.

Exhaust Stack

As shown on Figure 9b.1-1, the exhaust air from HCF Zone 1a is directed to the HCF Zone 1a exhaust stack, which is isolated from the balance of the HCF ventilation system. As described in Section 7b.7, the exhaust stack uses a radiation monitor to measure the airborne radioactivity in the filtered air that is exhausted downstream from the HCF Zone 1a and fans.

The consequence analyses in Chapter 13b are performed for a stack release and for a ground release. As shown in Table 13b.4-1, in all cases analyzed, a ground release results in greater dose to the public than a stack release, and the results for the ground release are lower than the acceptance limits. The HCF Zone 1a exhaust stack is a nonsafety-related SSC.

Power Supply

The HCF Zone 1a portion of the HCF ventilation system requires safety-related backup power for the fans and dampers. As described in Section 8.3, uninterruptible power is supplied via a UPSS that includes a battery, battery charger, and inverter combination sized to ensure continuity of power for a sufficient time to allow the connected loads to perform their safety function. Figure 8.3-1 depicts the UPSS component configuration.

6b.2.3 COMPLIANCE WITH DESIGN CRITERIA

The following DC apply to the design of the HCF Zone 1a ventilation system:

- DC 8, Instrumentation and Controls: The design for the HCF Zone 1a ventilation system includes instrumentation and controls to monitor and control the behavior of the system within prescribed operating ranges during normal operation, anticipated operational occurrences, and accident conditions.
- DC 10, Confinement: The HCF Zone 1a ventilation system is designed to support the establishment of low-leakage barriers against uncontrolled releases of radioactivity to the rest of the facility and the environment and to ensure that effluent released from HCF Zone 1a is filtered and discharged through the HCF Zone 1a exhaust stack.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The HCF Zone 1a ventilation system is designed to control the release of radioactive material in gaseous effluents during normal production operation, anticipated operational occurrences, and accident conditions.
- DC 21, Monitoring Radioactivity Releases: the HCF Zone 1a ventilation system is designed to provide for monitoring the effluent discharge paths from HCF Zone 1a for radioactivity that may be released during normal production operation, including anticipated operational occurrences, and from postulated accidents.

- DC 22, Inspection, Testing, and Maintenance: The design for the HCF Zone 1a ventilation system includes provisions for inspection, testing, and maintenance to ensure availability and reliability to perform the credited functions.

6b.3 CONTAINMENT

The HCF does not employ a containment SSC.

6b.4 EMERGENCY COOLING SYSTEM

There is no emergency cooling system associated with the HCF.

6b.5 NUCLEAR CRITICALITY SAFETY PROGRAM IN THE HOT CELL FACILITY

Nuclear criticality safety (NCS) is ensured by designing the HCF and supporting SSCs with safety margins such that safe conditions are maintained under normal and abnormal operations and design basis accidents. The HCF is designed and operated with a preference for nuclear NCS controls in the following order:

a. Passive engineered
b. Active engineered
c. Enhanced administrative
d. Simple administrative

The HCF is designed, constructed, and operated such that a nuclear criticality event is prevented. An accidental criticality event is highly unlikely because the HCF is designed and operated with these NCS control features.

Potential hazards to the worker, the public, or the environment in any planned processing operation or handling and transport in the HCF have been identified and evaluated in the preliminary Integrated Safety Analysis (ISA) conducted in accordance with NUREG-1513, Integrated Safety Analysis Guidance Document. Refer to Chapter 13b. The evaluation established the critical masses associated with the activities conducted during facility operations and suggested controls applying the double contingency principle. The results of the preliminary ISA were used to identify passive safety features, as well as other safety features of the facility design.

6b.5.1 NUCLEAR CRITICALITY SAFETY PROGRAM

Eden maintains a Nuclear Criticality Safety Program (NCSP) for the HCF that complies with applicable ANSI/American Nuclear Society (ANS) standards, as endorsed by Regulatory Guide 3.71, Nuclear Criticality Safety Standards for Nuclear Materials Outside Reactor Cores, Revision 3. The NCSP is established and implemented to meet the applicable criticality safety requirements of Title 10 of the Code of Federal Regulations (10 CFR) Part 50 and 10 CFR Part 70. The NCSP implements the guidance provided in ANSI/ANS-8.19-2014, Administrative Practices for Nuclear Criticality Safety (R2024) (ANSI/ANS, 2024).

The NCSP is administered through a written NCS policy and program description, with an additional program description for NCS training and qualification. The NCSP is executed by qualified NCS staff using written procedures. The program description and written procedures are formally controlled through the Eden document control procedure.

The goal of the NCSP is to ensure that workers, the public, and the environment are protected from the consequences of a nuclear criticality event. In order to accomplish this goal, all practicable measures are implemented to prevent an inadvertent criticality from occurring. The NCSP also contains provisions necessary to mitigate the consequences (i.e., criticality accident alarm system [CAAS] and emergency response activities) should an inadvertent criticality occur.

6b.5.1.1 Compliance with National Consensus Standard

The NCSP will comply with the following standards as endorsed by Regulatory Guide 3.71 with clarifications or exceptions:

- ANSI/ANS-8.1-2014, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors (R2018) (ANSI/ANS, 2018).
- ANSI/ANS-8.3-1997, Criticality Accident Alarm System (R2017) (ANSI/ANS, 2017a).
- ANSI/ANS-8.10-2015, Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement (R2020) (ANSI/ANS, 2020a).
- ANSI/ANS-8.23-2007, Nuclear Criticality Accident Emergency Planning and Response (R2012) (ANSI/ANS, 2012).
- ANSI/ANS-8.24-2017, Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations (R2023) (ANSI/ANS, 2023).

In addition, the following standards will be used for guidance:

- ANSI/ANS-8.6-1983, Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ (R2002) (ANSI/ANS, 2002).
- ANSI/ANS-8.7-1998, Nuclear Criticality Safety in the Storage of Fissile Materials (R2017) (ANSI/ANS, 2017b).
- ANSI/ANS-8.19-2014 (ANSI/ANS, 2024).
- ANSI/ANS-8.20-1991, Nuclear Criticality Safety Training (R2020) (ANSI/ANS, 2020b).
- ANSI/ANS-8.21-1995, Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors (R2019) (ANSI/ANS, 2019).
- ANSI/ANS-8.22-1997, Nuclear Criticality Safety Based on Limiting and Controlling Moderators (R2021) (ANSI/ANS, 2021).
- ANSI/ANS-8.26-2007, Criticality Safety Engineer Training and Qualification Program (R2016) (ANSI/ANS, 2016).

6b.5.1.2 Management of the NCSP

The Eden Chief Operating Officer holds overall responsibility for the NCSP. The Radiation Protection Manager is the Responsible Manager for the NCSP and may delegate administrative authority to an NCS Lead.

Eden facility management holds the following responsibilities with respect to the NCSP:

- Formulating and maintaining the NCS policy and ensuring that personnel involved in operations with fissionable materials are knowledgeable about the program.
- Assigning responsibility and delegating commensurate authority to implement the NCS policy and NCSP.
- Ensuring that the facility staff, regardless of position, is made aware of their responsibilities for implementing the requirements of the NCSP.
- Ensuring that appropriately trained and qualified NCS staff are available to provide technical guidance appropriate for the operations involving fissionable materials performed at the HCF.
- Establishing and maintaining a training and qualification program for NCS staff.

- Establishing a system to monitor, review, appraise, and audit the effectiveness of all NCSP activities, procedures, and performance, including the review of the appraisal system itself. Audits to be performed at least once every three years.
- Establishing and maintaining a configuration management program that identifies and controls changes to facility, equipment, and processes important to NCS.
- Establishing a process for developing, reviewing, supplementing, and revising operating procedures important to NCS.
- Requiring that activities involving fissile material are conducted using approved written procedures and, for situations for which existing procedures are inadequate or do not exist, requiring personnel to take no action until the NCS staff has evaluated the situation and provided recovery instructions.
- Establishing and maintaining safe NCS practices and procedures.
- Conducting evaluations to ensure that all processes involving fissionable material remain subcritical, with an approved safety margin, for all normal and credible abnormal conditions.
- Establishing minimum qualification requirements in education, experience, and training for NCSP staff and for all facility personnel operating with or handling fissionable materials.
- Providing training to all operations personnel on the NCSP procedures for possessing and handling fissionable materials and on the response to an inadvertent criticality event.
- Establishing and maintaining a document control system for all documentation and records, including all NCSP evaluation reports.
- Identifying and documenting accident sequences that could lead to an inadvertent criticality event and taking measures to prevent their occurrence.
- Requiring personnel to report defective NCS situations to operations supervision and the NCS staff.
- Encouraging the use of stop-work authority and reporting of defective conditions.

Supervisory personnel involved in operations with fissionable materials hold the following responsibilities with respect to the NCSP:

- Accepting responsibility for the safety of operations under their control.
- Being knowledgeable in those aspects of the NCSP relevant to operations under their control.
- Ensuring that NCS training is provided to the personnel under their supervision.
- Ensuring that personnel under their supervision understand procedures, limits, controls, and other NCS considerations such that personnel can perform their functions without undue risk.
- Completing training, and ensuring that workers under their supervision complete training, before performing fissile material operations, understanding and ensuring compliance with all applicable criticality safety controls, and reporting any proposed change in fissile

material operations to the NCS staff for evaluation and approval before the operation commences.

- Maintaining records of training activities and verification of personnel understanding.
- Developing or participating in the development of procedures applicable to the operations under their control. Maintaining these procedures to reflect changes in operations as a continuous supervisory responsibility.
- Verifying compliance with NCS specifications for new or modified equipment before its use. Verification may be based on inspection reports or other features of the Quality Assurance Program.
- Being responsible for the inspection, testing, and maintenance of engineered controls.
- Requiring conformance with good safety practices, including unambiguous identification of fissile materials and good housekeeping.

NCS staff hold the following responsibilities with respect to the NCSP:

- Providing oversight of NCS and the NCSP at the Eden Isotope Production Complex.
- Maintaining familiarity with operations within the HCF requiring NCS controls. This shall be accomplished by individual staff members maintaining familiarity with operations for which they provide guidance.
- Providing technical guidance for the design of equipment and processes and for the development of operating procedures.
- Maintaining familiarity with current developments in NCS standards and guides and other nuclear criticality information.
- Performing Criticality Safety Evaluations (CSEs).
- Establishing the need for and location of any criticality accident alarms per ANSI/ANS-8.3-1997 (ANSI/ANS, 2017a).
- Participating in the development of the NCSP training program. Assisting facility managers and supervisors in training personnel.
- Reviewing facility non-conformances that have the potential to impact NCS and providing appropriate response recommendations to violations or deficiencies.
- Meeting and maintaining the NCSP qualification requirements established by facility management with the guidance of ANS standards for education, training, and experience.
- Being proficient in the application of NCS safety modelling tools.
- Requiring conformance with good safety practices, including unambiguous identification of potential NCS issues.

The NCS Lead, to be designated by the Radiation Protection Manager, is responsible for implementation of the NCSP. The NCS Lead maintains a staff that includes trained and qualified Criticality Safety Engineers and supporting staff to perform CSEs. The NCS Lead and all NCS staff members must have the requisite experience in the application of NCS programs. Educational requirements and experience levels of the NCS Lead and NCS staff members will be provided in the Operating License Application.

6b.5.1.3 NCS Change Management

Changes that involve or could affect SNM are evaluated under 10 CFR 50.59. Such changes include new design, operation, or modification of existing SSCs; computer programs; processes; operating procedures; or administrative controls. Prior to implementing the change, it shall be confirmed that the entire process is subcritical (with approved margins for safety) under both normal and credible accident scenarios. The above process for NCS change management is in accordance with ANSI/ANS-8.19-2014 (ANSI/ANS, 2024).

6b.5.1.4 Planned Response to Criticality Accidents

The CAAS is used as described in Subsection 7b.7.3. The CAAS provides for detection and annunciation of criticality accidents. Emergency procedures shall be prepared and approved by management. Refer to Section 12.7 for a summary description of the preliminary Eden Emergency Plan.

HCF operations personnel shall be trained in evacuation methods and informed of routes and assembly stations. Instrumentation and procedures are provided for determining the radiation in the evacuated area following a criticality accident. Information is collected in a central location.

Emergency procedures for each area in which SNM is handled, used, or stored are maintained to ensure that all personnel withdraw to an area of safety upon the sounding of the alarm. The procedures include conducting drills to familiarize personnel with the evacuation plan, designation of responsible individuals for determining the cause of the alarm, and placement of radiation survey instruments in accessible locations for use in such an emergency.

Fixed and personnel accident dosimeters are provided in areas that require a CAAS. These dosimeters are readily available to personnel responding to an emergency, and there is a method for prompt on-site dosimeter readouts.

6b.5.2 CRITICALITY SAFETY CONTROLS IN THE HCF

The major controlling parameters used in the HCF are geometry control and/or limitations on the mass of SNM. CSEs are used to identify the significant parameters affected within a particular system. The CSEs including assumptions relating to processes, equipment, material function, and operation, and credible accident scenarios, are justified, documented, and independently reviewed. Where possible, passive engineered controls are used to ensure NCS. The use of geometry as a controlled parameter is acceptable because all dimensions and nuclear properties that use geometry control are verified.

Operations in the HCF for which NCS is a concern involve low-enriched uranium (LEU) in the following forms:

- Targets containing LEU metal foils.
- Solutions of LEU dissolved in acid.
- Oxides of recovered LEU in powder form.
- Metal ingots of LEU.
- Metal LEU foils for use in target assembly.
- LEU mixed with process waste in solid form.

Incidental quantities of other fissionable actinides are produced as a result of neutron activation of uranium (U) during target irradiation in the reactor. Fissionable actinides contribute less than 0.04 percent of the fissionable mass in a target exposed for the maximum duration and are generally ignored.

6b.5.2.1 LEU Flow in the EMIF

The LEU flow path in the EMIF consists of irradiating LEU targets in the reactor, transferring irradiated targets to the HCF target processing canyon, and dissolving the LEU metal foil from the target to allow extraction of the molybdenum-99 (Mo-99) and other saleable fission products. The Mo-99 is purified for packaging and shipment to the customer using the modified Cintichem process described in Chapter 4b. The LEU is purified for recycling using the uranium extraction (UREX) process. The Mo-99 is packaged for shipment while the LEU is placed in storage as oxide powder for subsequent reduction to metal to be used in assembly of new targets.

The flow of LEU through the EMIF is described in Chapter 4b. The processing operations are conducted in a batch mode. The general steps of the LEU flow path are as follows:

a. Irradiated targets are moved from the transfer canal to the first processing SCB (SCB 1, target receipt box) in the target processing canyon and are prepared for processing.
b. Irradiated targets are segregated and moved to a designated dissolver box (SCB 2 – 5) for LEU foil dissolution.
c. Up to six irradiated targets are processed in a dissolver box at one time. The LEU foils are separated from the aluminum cladding and dissolved as a batch in nitric acid in a sealed dissolver unit. After recovery of the Mo-99, the LEU/fission product solution is staged in the dissolver box for decay for a period of several days.
d. The LEU/fission product solution is moved from the dissolver box to a UREX box.
e. The UREX process is performed, separating the LEU from the solution and converting it to an oxide.
f. The recovered LEU oxide is packaged in a container and transferred to the SNM storage area.
g. The LEU oxide is combined with other batches and converted to a metal ingot in the target fabrication area. Metal ingots are stored in the SNM storage area.
h. LEU metal ingots are rolled into foils in the target fabrication area. Foils are cut to size and shaped into cylinders. Foils are then plated with nickel (Ni). Ni plated foils are stored in the SNM storage area.
i. Targets are hydroformed in the target fabrication area. Targets are stored in the SNM storage area.
j. Targets are transferred to the target receipt box for movement to the transfer canal.

6b.5.2.2 Criticality Safety Evaluations

CSEs are performed to ensure that nuclear processes remain subcritical during both normal and accident scenarios. An approved margin of subcriticality is included in these CSEs. NCS is analyzed for each activity, including the design features of the systems or components and the operating practices. The analysis of individual systems or components and their interaction with other systems or components containing LEU is performed to ensure the NCS criteria are met.

A preliminary evaluation for each processing activity involving LEU was performed using ANSI/ANS-8.1-2014 (ANSI/ANS, 2018) and the neutronics code MCNP (Monte-Carlo N-particle). The preliminary evaluation report is used for supplemental guidance in establishing the SSCs for the HCF. No attempt was made to formally quantify bias or bias uncertainly of the k_{eff} (effective neutron multiplication factor) results. The results of this study were also used to support the accident analyses described in Chapter 13b. Formal quantification of k_{eff} bias and bias uncertainty will be included in the CSEs.

All operations with LEU material in the SCBs of the target processing canyon are performed within the safety-related biological shielding as described in Chapter 4b. An inadvertent criticality event in an SCB is not credible due to the incorporation of engineering and administrative measures into design and operation.

The preliminary evaluation report considered nuclear criticality concerns in the HCF for the following topics:

- SNM storage area.
  - Targets.
  - Uranium oxide (U_3O_8)/uranium dioxide (UO_2) powder.
  - U metal ingots.
  - U metal foils.
- Target transfer from SNM storage area to target receipt box.
- Target receipt box.
- Dissolver box.
- UREX box.
- Waste packaging box.
- Waste storage canyon.
- Target fabrication area.
  - Foil rolling.
  - Ni coating.
  - Target fabrication.
  - Uranium oxides (U_3O_8/UO_2) to U metal conversion.

6b.5.2.2.1 SNM Storage Area

The SNM storage area in the HCF accommodates a) targets, b) U_3O_8/UO_2 powder, c) U metal ingots, and d) U metal foils in a secure and criticality safe condition. At any one time there may be materials in any of these four forms in the SNM storage area. The forms are segregated and maintained in custom designed containers, drawers, and racks that are designed to be criticality safe in both dry and flooded conditions. The use of moderator materials in the design of the containers, drawers, and racks is minimized.

A total of [[ ]]SRI of uranium-235 (U-235), equivalent to about [[ ]] SRI of LEU at 19.75 percent enrichment in U-235, is stored in the SNM storage area. Lower enriched material may also be present. The design and configurations for containers, drawers, and racks within the SNM storage area will be presented in the Operating License Application. A CAAS is required for the SNM storage area to provide defense-in-depth for worker safety.

6b.5.2.2.2 Target Receipt Box and Target Transfer

Both fresh targets and irradiated targets are transferred through the target receipt box. Fresh targets are removed from the SNM storage area and transferred to the target receipt box in a target carrier. The target carrier is placed in the fresh target transfer basket, a feature of the target transfer system. The fresh target transfer basket is moved through the transfer canal to the reactor pool. Irradiated targets are moved through the transfer canal to the target receipt box. After a decay period, the irradiated target transfer basket is unloaded, and the targets are prepared for dissolution. The irradiated targets are moved to their designated dissolver box for disassembly and dissolution.

The LEU physical form in the target receipt box or transfer canal is fresh or irradiated targets. The number of targets that can be in the target receipt box or transfer canal at any one time is as follows:

- 60 fresh targets.
- 60 irradiated targets.

Dry targets (120) cannot be made into a critical configuration. The calculated k_{eff} for a 120 dry target array with the targets touching in a triangular pitch is less than 0.1. The quantity of U-235 for 120 targets using the reference target design presented in Chapter 4a is about [[ ]] PROP/ECI/SRI. The ANSI/ANS 8.1-2014 Section 5.3 Metallic Units Table 3 (Single-parameter subcritical limits for metal units) limit is 20.1 kg (44.3 lb.) U-235 (ANSI/ANS, 2018).

Targets (60) loaded in a target carrier in the transfer canal maintain a calculated k_{eff} value of less than 0.9.

6b.5.2.2.3 Dissolver Boxes and UREX Boxes

LEU in solution form is processed in the dissolver boxes and UREX boxes. The ANSI/ANS 8.1-2014 Section 5.1 Uniform Aqueous Solutions Table 1 [Single-parameter subcritical limits for uniform aqueous solutions of fissile nuclides – U-235 in $UO_2(NO_3)_2$] limit is 780 grams (g) (1.7 lb.) U-235 (ANSI/ANS, 2018). The quantity of U-235 for 30 targets using the reference target design presented in Chapter 4a is about [[ ]] PROP/ECI/SRI U-235. The U-235 mass limit for each of the four dissolver boxes and two UREX boxes is 780 g (1.7 lb.) U-235 each.

6b.5.2.2.4 Waste Packaging Box and Waste Storage Canyon

The UREX process is estimated to be greater than 99.9 percent efficient in removing the LEU from the fission product and actinide solution. Because only trace quantities of fissile materials remain in the waste stream, there are no criticality concerns in the waste storage canyon.

6b.5.2.2.5 Transfer of LEU Oxide

The LEU oxide powder generated from the UREX process is transferred from the UREX boxes to the SNM storage area. The ANSI/ANS 8.1-2014 Section 5.4 Oxides Table 4 (Single-parameter subcritical limits for oxides containing no more that 1.5 percent water by weight at full density) limit is 32.3 kg (71.2 lb.) U-235 (ANSI/ANS, 2018). The U-235 mass limit for a LEU oxide transfer container is 780 g (1.7 lb.) U-235.

6b.5.2.3 Criticality Accident Alarm System

A CAAS, meeting the requirements of 10 CFR 70.24 as described in Subsection 7b.7.3, is located in the HCF and configured to monitor the following zones where the potential for a criticality accident exits:

- HCF SNM storage area.
- HCF target processing canyon.
- HCF target fabrication area.

6b.5.3 SURVEILLANCE REQUIREMENTS

A review of surveillance requirements to ensure the availability and reliability of safety controls when required to perform safety functions will be included in the Operating License Application.

6b.6 HOT CELL FACILITY ENGINEERED SAFETY FEATURES TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

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Chapter 7
Instrumentation and Control Systems

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Preliminary Safety Analysis Report

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Chapter 7a
Reactor Facility Instrumentation and Control Systems

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CHAPTER 7a
REACTOR FACILITY INSTRUMENTATION AND CONTROL SYSTEMS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
ac	alternating current
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARM	area radiation monitor
BOP	balance of plant
CAM	continuous air monitor
DC	design criteria
EIPC	Eden Isotope Production Complex
ESF	engineered safety features
FCS	facility control system
ft.	feet
HCF	Hot Cell Facility
hr.	hour(s)
I&C	instrumentation and control
IER	insertion of excess reactivity
LEP	loss of normal electrical power
LOC	loss of coolant
LOF	loss of coolant flow
m	meter(s)
MHA	maximum hypothetical accident
MPS	magnet power supply

Acronym/Abbreviation	Definition
mrem	millirem(s)
OCDS	operator control and display system
PRNI	power range nuclear instruments
PSAR	Preliminary Safety Analysis Report
QAP	Quality Assurance Program
RF	Reactor Facility
RMS	radiation monitoring system
RPS	reactor protection system
SL	safety limit
SSC	structure(s), system(s), and component(s)
U.S.	United States
WRNI	wide range nuclear instruments

7a Reactor Facility Instrumentation and Control Systems

The purpose of the Reactor Facility (RF) instrumentation and control (I&C) systems is to 1) allow for monitoring the status of the reactor, associated reactor subsystems, and environmental conditions in the RF, 2) control the reactor power by adjusting the reactivity state of the reactor, 3) maintain active features to automatically shut down the reactor if conditions exceed the operating limits for the reactor, and 4) control the operation of selected components in the reactor subsystems and RF.

The I&C systems include the RF control system (facility control system, FCS), the reactor protection system (RPS), the radiation monitoring system (RMS), and the operator control and display system (OCDS). For the RF, there is no I&C system required to initiate engineered safety features (ESFs).

7a.1 SUMMARY DESCRIPTION

The all-target reactor is an open-pool, non-power research reactor that operates at a steady-state power level of 1.8 megawatts thermal. There is no prompt critical pulsing capability. There are no requirements for active core cooling or power and temperature monitoring when the reactor is shut down. No ESF actuation is required of the I&C systems.

The I&C systems are comprised of sensors, circuitry, displays, and actuating devices that provide the information and the means to safely control the reactor and to prevent or mitigate accidents. Instruments are provided to monitor and indicate reactor and reactor support system process variables such as reactor power and rate of change in power, core coolant inlet temperature, radiation levels (general area and airborne) throughout the RF, and pool level. One of the primary functions of the I&C system is to automatically shut down the reactor (scram) when certain reactor parameters are outside the acceptable range as presented in Chapter 14. The I&C systems also provide for the acquisition and storage of RF parameters to support fuel burnup calculations and equipment status.

The I&C systems use both analog and digital technology. The RPS uses no software/digital components to perform its safety function. The FCS, RMS, and OCDS use software signal processing and digitally programmed logic.

Within the reactor control room, the control console provides reactor and reactor support systems controls and indication of reactor and reactor support systems parameters. Operation and monitoring of support systems, such as reactor coolant pumps and heat exchangers, coolant systems valve lineups, and facility access controls, may be performed in the reactor control room.

Figure 7a.1-1 shows a simplified one-line block diagram of the I&C systems components and connections. RPS components and connections are depicted in red.

7a.1.1 FACILITY CONTROL SYSTEM SUMMARY

The FCS is used to monitor and control the reactor and contains all the instrumentation, controls, and interlocks necessary for startup, operating in the steady-state mode from startup to full power conditions, and shutdown. Rod control components include rod position indicators, rod drives, operational interlocks, and redundant wide-range linear and log power channels. The purpose of this system is to provide the reactor operator with specific and accurate information

about reactor parameters over the entire range of operations. Functional interlocks ensure that operational steps are performed in the proper and approved sequence in all operating modes. Balance of plant (BOP) instrumentation monitors and controls non-nuclear reactor and RF parameters and systems during operation. BOP functionality performs no protective functions. The BOP parameters monitored and controlled include the ventilation system, the coolant system, the coolant cleanup system, and the coolant makeup system.

Rod Control

Reactor power is controlled by positioning control and safety rod drives to start up the reactor, operate the reactor at steady-state conditions, and shut the reactor down. The rod control functionality is part of the digital FCS that controls and indicates position of the safety and control rods.

There are four control rods and one safety rod. The construction of the safety and control rods and their design reactivity are presented in Chapter 4a.

Balance of Plant Functions

The BOP structures, systems, and components (SSCs) include instrumentation used to monitor and control non-nuclear RF parameters and systems during operation. This functionality performs no protective function and does not prevent protective actions from being completed. The systems monitored and controlled by the BOP include the ventilation system, the coolant system, the coolant cleanup system, and the coolant makeup system.

7a.1.2 REACTOR PROTECTION SYSTEM SUMMARY

The RPS is considered safety-related. It provides measurement and display of reactor power, reactor period, pool coolant level, and core coolant inlet temperature parameters. Each of these parameters function as independent channels that provide their own trip signals when a single parameter measurement exceeds its setpoint. Trip signals directly cause scram actuation for non-redundant channels. Redundant channels apply coincidence logic to trip signals with redundant trains to decide scram actuations.

Nuclear Instruments

The wide range nuclear instruments (WRNI) are used to measure the nuclear process variables of reactor power and rate of change of reactor power (reactor period). The power range nuclear instruments (PRNI) provide linear indication of reactor power over the top three decades of reactor power as percent power. The nuclear instruments are described in more detail in Section 7a.4.

Core Coolant Inlet Temperature

The core coolant inlet temperature instruments are used to monitor the non-nuclear process variable of core coolant inlet temperature. The core coolant inlet temperature is measured in the downcomer as coolant enters the lower plenum of the reactor pool. The core coolant inlet temperature instruments are described in more detail in Section 7a.4.

Pool Coolant Level

The pool level instruments are used to monitor the non-nuclear process variable of pool coolant level. The pool coolant level instruments are described in more detail in Section 7a.4.

Manual Scram

A manual scram is provided to the operator to allow scram action at the operator's discretion. The manual scram directly opens contacts in the scram bus, bypassing the logic circuits of the RPS.

Rod Drop Reactivity Shutdown

There are four control rods and one safety rod. The construction of the control and safety rods and their design reactivity are presented in Chapter 4a. Electromagnets on each control and safety rod drive mechanism magnetically couple the armature of the control or safety rod to the rod drive mechanism. When a scram condition is not present or bypassed to the magnet power supply (MPS) relay circuit, the magnets are energized. When a scram condition exists, the electromagnets are de-energized, and the control and safety rods drop by gravity to their full-down position into the core. Any scram releases all the control and safety rods to safely shut the reactor down regardless of the position or movement of the rods.

7a.1.3 OPERATOR CONTROL AND DISPLAY SYSTEM SUMMARY

The OCDS provides a centralized display of current reactor and reactor support process variables and status of important reactor systems equipment needed for the operator to operate the reactor safely and conveniently in all modes. Variables indicated on OCDS displays are provided by the FCS, RMS, and RPS. There are two groupings of displays and controls on the OCDS at the control console: 1) reactor protection and 2) Balance of Plant. A summary description of the functions, information displayed, and method of display are presented below.

Reactor Parameters Display & Controls

The reactor parameters display is the primary display that the reactor operator uses to control the reactor at the operator console. The digital display indicates reactor power, reactor period, pool coolant level, core coolant inlet temperature, and control and safety rod positions. The primary inputs to the reactor control display are isolated signals from the WRNI, PRNI, pool coolant level sensor, and core coolant inlet temperature thermocouples.

The reactor parameters analog display is comprised of hard-wired discreet panel meters and indicating lamps that display the isolated analog signals of the WRNI, PRNI, pool coolant level, core coolant inlet temperature channels, and rod position information. The reactor display panel meters show the output of all the RPS parameter channels and rod control measuring channels simultaneously. The analog indications provide a measure of defense-in-depth to their digital counterparts.

The reactor operation controls allow the operator to maintain control of the reactor power within specified limits. Rod raise/lower controls manipulate the position of each control and safety rod as allowed by the logic interlocks applied by the FCS. Pressing a scram button immediately scrams the reactor.

Balance of Plant Display & Controls

The BOP display is used to indicate selected secondary reactor support equipment necessary for safe and efficient operation of the RF. Information from the RMS instruments is also displayed on discrete panel meters.

BOP operator controls are provided on the operator console in the form of switches and buttons. Motor controls allow the operator to turn on/off coolant pumps and blowers.

Hot Cell Facility Display

The Hot Cell Facility (HCF) I&C is described in Chapter 7b. The design of the HCF control system is specific to the radiological hazards present in the HCF. The ventilation system instrumentation and RMS are HCF I&C systems that are important to safe operations, of which important variables are displayed on the OCDS. Refer to Chapter 7b for HCF parameters to be displayed by the OCDS.

7a.1.4 RADIATION MONITORING SYSTEM SUMMARY

The radiation monitoring instrumentation consists of portable instrumentation and environmental monitoring, as determined by the needs of the Radiation Protection Program, and permanently installed instrumentation, referred to here as the RMS. This section is limited to a description of the RMS.

The RMS monitors radiation levels throughout the facility to ensure they are maintained within safe bounds for both workers and the public and to ensure continued compliance with regulatory and technical specifications requirements. Design features include measures to detect leakage to minimize the potential to spread contamination. Releases are detected by the RMS either through monitoring contamination, monitoring effluents, or monitoring airborne radioactivity within the Eden Medical Isotope Facility. The RMS also monitors radioactive waste handling systems and storage areas. The RMS associated with the HCF is described in Section 7b.7.

Area radiation monitors (ARMs) are located in the RF high bay to constantly monitor the radiation levels in the area. The ARMs output signals to the OCDS for indication and annunciation at the operator console. The ARMs also have built-in local radiation level indication and audible and visual alarms.

Continuous air monitors (CAMs) sample for airborne radioisotopes in the RF high bay and in the exhaust air in the RF high bay exhaust stack. The CAMs output signals to the OCDS for remote indication and annunciation at the operator console. The CAMs have built-in local radiation level indication and audible and visual alarms.

7a.2 DESIGN OF INSTRUMENTATION AND CONTROL SYSTEMS

The design of the I&C system complies with the guidance provided in American Nuclear Society (ANS) and American National Standards Institute (ANSI) standard ANSI/ANS 15.15-1978, Criteria for the Reactor Safety Systems of Research Reactors (R1986) (ANSI/ANS, 1986), and in NUREG 1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content. ANSI/ANS 15.15-1978 has been accepted as the appropriate guidance to the research and non-power reactor community in lieu of an ad hoc application of similar standards developed specifically for the power reactor community. The appropriate graded approach has been applied to the design basis of the I&C system commensurate with the level of risk associated with operation of the reactor as presented in the accident analysis in Chapter 13a. The I&C system is designed and constructed in accordance with the requirements of the Eden Quality Assurance Program (QAP).

7a.2.1 DESIGN CRITERIA

The design of the I&C is specific for the steady-state, open-pool, low-enriched non-power reactor.

7a.2.1.1 Design Criteria from Chapter 3

The following design criteria (DC) sourced from Chapter 3 apply to the design of the RF I&C systems:

- DC 6, Reactor Design: The reactor control, and protection systems shall be designed with appropriate margin to ensure that specified target design limits are not exceeded during normal operation, anticipated operational occurrences, and accident conditions.
- DC 8, Instrumentation and Control: Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to ensure adequate safety. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.
- DC 12, Control Room: A control room shall be provided from which actions can be taken to operate the reactor safely under normal conditions and anticipated operational occurrences.
- DC 13, Protection System Functions, Reliability, Testability, Independence, and Failure Modes: The protection system shall be designed to automatically initiate protective functions which ensure that target design limits are not exceeded. The protection system shall be designed for high functional reliability commensurate with the safety functions to be performed.
- DC 14, Combined Reactivity Control Systems Capability, Reactivity Limits, and Protection Against Anticipated Operational Occurrences: A reactor control system shall be designed to reliably control reactivity changes to ensure that, under accident conditions and with appropriate margin for a maximum worth stuck rod, acceptable target design limits are not exceeded. The reactivity control system shall be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that the effects of postulated reactivity accidents cannot result in damage to the reactor target cladding or coolant boundary.

- DC 19, Radioactive Material Control: Appropriate systems shall be provided in the facility (1) to detect conditions that may result in excessive radiation levels and (2) to initiate appropriate safety actions. These systems shall be designed with the capability to permit appropriate periodic inspection and testing.
- DC 21, Monitoring Radioactivity Releases: Means shall be provided for monitoring the RF atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operation, anticipated operational occurrences, and accident conditions. Means shall be provided, where necessary, to monitor radiation levels.
- DC 22, Inspection, Testing, and Maintenance: The design of safety-related SSCs shall provide for adequate inspection, testing, and maintenance, to ensure their availability and reliability to perform their safety function when needed.

7a.2.2 DESIGN BASIS

The information in this section provides the design bases for I&C functions primarily required to mitigate the accident analyses of Chapter 13.

Quality Level

Vendors supplying I&C SSCs that execute or support protective functions are to provide platform qualification certificates that show that the system is designed to operate under anticipated environmental conditions. The system development, installation, and initial testing follow the vendors' QAP with concurrence of Eden Isotope Production Complex (EIPC) engineering and operations. Installation and testing follows the requirements of the Eden QAP. Software quality assurance, where needed, and verification and validation are also performed according to the vendor specifications and the Eden QAP. Acceptance criteria following installation are developed by the vendor with the concurrence of EIPC engineering and testing is performed by the vendor and the EIPC operations staff in accordance with the Eden QAP.

Major components such as the nuclear instruments are selected based on current deployment and proven record of reliability within the United States (U.S.) research reactor community as approved and licensed by the U.S. Nuclear Regulatory Commission or Department of Energy in the United States.

Fire Protection

The RPS and OCDS SSCs are located in the reactor control room where at least one operator is stationed when the reactor is in the operating mode. The operator takes action to shut down the reactor in the event of a fire in the reactor control room or general RF. Non-combustible material are prioritized for use in the RPS components.

Environmental and Dynamic Effects

The I&C systems are located within the protective structure of the RF building and within areas considered mild environments. No hazardous effects are considered plausible risks to the safe operation or shutdown of I&C SSCs credited in the accident analysis.

Design Limit Margin

Consistent with DC 6, design limits such as, but not limited to, trip parameter setpoint and reactivity insertion rate are calculated to provide adequate margin against reaching safety limits (SLs).

Instrumentation and Control

Consistent with DC 8, each system described in this chapter monitors reactor and facility parameters for the purposes and over the ranges as described.

Accident Analysis-Derived Parameters

Consistent with DC 8, maintaining adequate coolant volume and temperature in the reactor pool is critical for ensuring adequate cooling of the reactor core to protect target cladding. Limiting core coolant inlet temperature and peak target power ensures that the critical heat flux is not exceeded.

Monitored Variables

Consistent with DC 8, the I&C system design requirements have been derived from the descriptive chapters in the Preliminary Safety Analysis Report (PSAR) and the applicable credited controls applied in the accident analysis in Chapter 13a.

The safety of the reactor is based on protecting the integrity of the target cladding under all credible conditions. The target cladding temperature is an SL but cannot be directly measured. However, as presented in Section 4a.6, target cladding remains well below the SL if the reactor is operated below the maximum allowable setpoint, 45 degrees Celsius (°C) (113 degrees Fahrenheit [°F]), for core coolant inlet temperature. Limits on core coolant inlet temperature, pool coolant volume, and peak target power ensure that reactor coolant remains subcooled and below the critical heat flux conditions.

Reactor Control Room Occupancy

Consistent with DC 12, the operator control console is located in the reactor control room. The console provides manual scram, reactivity controls, and the requisite indications supporting operator decisions.

Automatic Safety Limit Protection

Consistent with DC 13, the RPS monitors process variables that protect the technical specification SLs. In the event of an RPS or FCS system anomaly that does not result in an automatic reactor shutdown (scram), the operator has sufficient information to identify problems and take corrective actions or initiate a manual scram.

Single Failure Criteria

Consistent with DC 13, redundant systems measure the process variables monitored by the RPS to ensure that no failure of a single measuring channel prevents automatic protective actions. The protection system uses a minimum of two independent, redundant RPS trains, each capable of initiating a scram. Sensor cables between the junction box at the reactor pool

and the RPS are enclosed in separate conduit runs for protection from mechanical damage and for train independence.

Redundancy

Consistent with DC 13, the RPS includes redundancy in its basic design philosophy, as recommended in ANSI/ANS 15.15-1978 (ANSI/ANS, 1986), to ensure that the system operates reliably under all anticipated conditions. Simple redundancy is provided by monitoring each of the reactor process variables (reactor power, reactor period, and core coolant inlet temperature) with redundant equipment (up to three independent channels) contributing to satisfying the intent of the single failure criteria for reactor safety systems.

Redundant RPS trains are identical and use an independent neutron monitoring system to determine the reactor power and period.

2-out-of-3 Coincidence

Consistent with DC 13, the RPS applies 2-out-of-3 channel coincidence to critical safety parameters to provide both redundancy and operational reliability for safe reactor operations. Coincidence requires that two channels of a process variable (power, period, temperature) must simultaneously send a channel trip condition to the RPS logic circuits to initiate a reactor scram. Three channels of reactor power, reactor period, and core coolant inlet temperature are monitored by the RPS. At least two channels are required to be operating as presented in the technical specifications when the reactor is in the operating mode. If a trip condition of two redundant process variable monitoring channels exists, a reactor scram occurs.

This 2-out-of-3 coincidence feature prevents spurious trips (e.g., noise spikes) of a single measuring channel from causing a scram if actual conditions do not warrant protective action. It also allows for a channel to be taken out of service while the reactor is operating if the other two channels are operational.

Independence

Consistent with DC 13, redundant RPS trains are separated in panels in the reactor control room. A separate conduit containing sensor cables from each RPS train is routed to individual compartments in the reactor bridge junction box in the RF high bay. The physical separation used in the RPS design are adequate to ensure that a single credible accident does not simultaneously degrade redundant trains.

Electrical isolation between systems, physical separation of redundant trains, and independence of communications among systems is applied to the I&C architecture to prevent common cause failures such as electrical fault propagation and negative effects of nonsafety-related components preventing the RPS from performing its safety function, that is, automatic scram.

Diversity

Consistent with DC 13, functional diversity is provided by monitoring multiple, diverse process variables associated with the reactor accident analysis that provide the reactor scram function: (1) reactor power, (2) reactor period, (3) pool coolant level, and (4) core coolant inlet temperature. A manual scram (5) is also available to the operator at all times, providing additional diversity in the design.

Technical diversity is provided by employing separate process variables – reactor power and period, pool coolant level and core coolant inlet temperature.

Surveillance, Periodic Checks, and Tests

Consistent with DC 13, each RPS train is designed to allow offline testing and calibration functions. The RPS is not designed to be tested while the reactor is operating. Maintenance procedures restrict test and calibration activities to when the reactor is shutdown. The “test” mode leaves the sensor signal in the circuit and capable of performing associated scram actions. Test signals are added to the sensor signal and initiate a reactor scram if performed while the reactor is operating. The “calibration” mode removes the sensor from the circuit and renders the channel non-operational. In calibration mode, a non-operation scram is inserted, preventing reactor operations.

Surveillance, periodic checks, and tests are performed routinely and calibrations are performed as required by the technical specifications and operation and maintenance procedures.

Credible failures in the I&C systems (e.g., high-scale or low-scale failure, ground faults, severed or crushed cables, disconnected sensors, loss of system communication) either automatically shut the reactor down or warn the operator of the condition.

Consistent with DC 22, the design of safety-related components in the RPS and FCS provide for adequate inspection, testing, and maintenance, to ensure availability and reliability to perform their safety function when needed.

Bypass

Consistent with DC 13, there are provisions for bypassing one channel of a given process variable for maintenance or other reasons, allowing for continuity of operations while maintaining redundancy and diversity. If a channel is placed out of service, a logic 0 is placed on its input to the scram logic voter circuit in the MPS. This sets the coincidence for the process variable that has a bypass inserted to 1-out-of-2. The ability to bypass is strictly controlled by procedure. Only one bypass is allowed on each channel at one time. The bypassed channel is indicated on the OCDS. The visual indication alarms until the bypass is removed from the channel. The bypassed channel is tested against its full operational criteria before it is put back into service and the bypass is removed.

Reactivity Control

Consistent with DC 14, the control rod drive mechanism of the RCS employs a mechanical limit to rod withdrawal speed to ensure reactivity insertion remains below the safety system setpoint limit.

Radiation Monitoring

Consistent with DC 19, radiation monitoring is provided to (1) detect conditions that may result in excessive radiation levels and (2) initiate appropriate safety actions.

Consistent with DC 21, radiation monitoring for the RF consists of monitoring of direct radiation exposure, airborne radioactivity, and high bay effluent releases.

Fail Safe

The RPS is designed to fail to a safe, de-energized state when critical functional and instrument faults are detected. The baseline, non-actuated state of protective instrumentation is a safe shutdown state. An energized signal is required to bring protective instrumentation to an operational, non-shutdown state.

The RPS scram signals are designed to revert to a de-energized state on the loss of electrical power. A de-energized RPS sends a de-energize signal to the MPS relay circuit, which initiates a scram condition, putting the reactor in a safe shutdown state. There are no backup power systems required following reactor shutdown upon a loss of power.

The RPS train share the same operating environment and a common source of alternating current (ac) power. Therefore, any failure in the ac power supply affects the entire RPS. The RPS trains continuously monitor internal power supply voltages. If any internal voltage falls outside of the design operating band, a scram is initiated. Also, on loss of power, the control and safety rods electromagnets are de-energized, disengage from the rod control system, and gravity-fall into the core.

During a loss of power, the reactor and subsystems are not required to be monitored.

Scram to Completion

Scram relay contacts are placed in series on both the supply and return sides of the scram bus to ensure reliability of the RPS. Any automatic scram action “latches-in” at the bistable until the operator manually resets the condition after the trip condition has cleared. All scram initiations go to completion. That is, any interruption of power on the scram bus results in de-energizing all control and safety rod drive electromagnets with the rods subsequently falling by gravity to their full-down (i.e., largest negative reactivity) position into the core.

7a.2.3 SYSTEM PERFORMANCE ANALYSIS

The I&C system has been designed to provide the monitoring of process variables and control of equipment necessary to operate the RF as described in other chapters in the PSAR. It also provides automatic reactor shutdown in the case of conditions that could lead to exceeding the SL. The trip levels of the RPS are set to automatically shut the reactor down with a safety margin that prevents reactor operational conditions that could exceed the SL.

The equipment and operating principles incorporated in the design of the I&C system have been chosen to provide a reliable I&C system that performs as described under all credible environmental reactor and reactor systems conditions.

7a.3 FACILITY CONTROL SYSTEM

The FCS provides the equipment needed to control the reactor from shutdown to full power and maintain operation at steady-state power. The FCS controls one safety rod and four control rods to provide the reactivity needed to adjust the reactor power level. OCDS process instrumentation informs the operator of specific characteristics of the coolant and RF atmosphere. The FCS also provides indications such as safety and control rod position, coolant temperature, coolant level, and atmospheric differential pressure at the OCDS and instrument racks in the reactor control room. The FCS is a digital system that uses programmable logic to enact interlocks and control functions.

7a.3.1 FACILITY CONTROL SYSTEM DESIGN BASES

The design bases for the FCS are as follows:

- Provide the operator with the ability to manually control all safety and control rod motion from the control console.
- Prevent inadvertent rod motion in manual mode by physically removing electrical power to the rod drive motor when rod movement is not desired (shim switch released).
- Ensure proper rod withdrawal sequence during startup per the stated interlock functionality.
- Provide for automatic control of the control rod bank to maintain reactor power at a selected steady-state power.
- Provide high resolution indication of each drive position between full-down and full-up positions.
- Provide limit switch indication of the extreme limits of travel and coupling of the rod itself.
- Provide limit switch indication when the rod is full-down.
- Limit the maximum rod drive speed to limit reactivity addition rates.
- Provide the operator with the ability to stop/start primary and secondary loop coolant pumps.
- Provide the operator with the ability to stop/start RF high bay exhaust stack fans.

7a.3.2 FACILITY CONTROL COMPONENTS AND FUNCTIONS

The parameters monitored and indicated by the FCS are listed in Table 7a.3-1. Monitored parameters specific to control rod and safety rod movement are listed in Table 7a.3-2.

7a.3.2.1 Reactivity Control

<u>Rod Drive Mechanisms</u>

The FCS provides for control and indication of the four control rod drives and the safety rod drive. The rod drive mechanisms are comprised of commercially available linear motion drives. The speed of the rod drive motor and resultant reactivity addition rate are determined by the

voltage level or frequency supplied to the rod drive motor, as controlled and limited by the mechanical design and FCS logic.

The control and safety rod drive mechanisms use a drive shaft that is moved linearly by the rod drive. The lower end of the drive shaft attaches to an electromagnet that when energized couples the armature at the top of the connecting rod to the drive mechanism so that rod drive motion causes the control or safety rod to follow.

The rod drives can be operated in the manual mode in which the operator controls the safety and control rods vertical positioning within the core. The operator selects the rods to be driven and moves them using the rod select switch and the rod shim switch located on the control console. The four control rods can be operated as a synchronized bank of rods.

The control rod bank can be operated in automatic mode in which the FCS controls the motor drive to maintain reactor power at a set level once steady-state conditions at the desired power level have been established. The desired power level is established manually by the operator and then switched to automatic mode.

Electromagnet Coupler

The electromagnets are supplied power by the MPS (see Section 7a.4). When a scram occurs, as described in Section 7a.4, the magnet power is interrupted, de-energizing the rod drive electromagnets, decoupling the connecting rod from the rod drive mechanism. The connecting rods and rods drop by gravity, inserting the poison section of the rods into the core to rapidly shut the reactor down. The control/safety rod drive is shown in Figure 7a.3-1.

Control Rod Manipulation

The four control rod drives can be normally operated as a bank with all four rods axially positioned at the same approximate height during reactor operation. Additionally, each control rod drive can be operated individually for testing and rod leveling. The rod drive up/down shim switches on the control console include the safety rod, control rod bank, control rod 1, control rod 2, control rod 3, and control rod 4. The shim switch has three positions: 1) stop, 2) up, and 3) down. The up and down positions energize the rod drive motor in the up or down direction. In the stop position, no power is supplied to the rod drive bus. The up and down positions are momentary contact in nature, requiring the operator to hold the switch in the up or down position to achieve rod motion. This ensures that deliberate action is required of the operator to cause the rod drive to move. When the switch is released, it returns to the stop position. An interlock limits the operator to single rod drive movement.

Rod Control Logic

The control scheme and logic of the FCS is coded with digital logic—receiving inputs from mechanical switches and neutron flux monitors then sending actuation signals to relays to perform its function. The logic interlocks in the FCS primarily restrict rod motion and maintain reactor power level. Interlocks specifically ensure that reactivity is inserted into the reactor in the proper order by blocking rod withdrawal unless the conditions for rod withdrawal are enabled by the rod control functionality. Deliberate operator action is required for rod drive movement to occur. Note that downward rod drive motion is always available to the operator with no interference from the interlocks and control of rod position cannot defeat a signal to scram the control and safety rods.

Reactivity Insertion Limit

To achieve delayed criticality in a controlled manner the control rod bank withdraw speed is limited to ensure reactivity addition rate is less than or equal to that specified in the technical specifications of Chapter 14. The limit of linear travel rate for the rod bank as translated from the reactivity additions rate is also specified in Chapter 14. This mitigates a design basis accident of Chapter 13 as listed in Table 7a.3-3.

Rod Withdraw Interlocks

The desired sequence of reactivity addition by the control and safety rods is ensured by interlocks that force the reactivity insertion sequence described above. There are two interlocks in the rod control subsystem:

- Safety rod withdrawal interlock – Safety rod withdrawal is prevented unless the four control rod drives are fully inserted into the core (i.e., “full-down” position).
- Control rod withdrawal interlock – Control rod withdrawal is prevented unless the safety rod drive is fully withdrawn (i.e., “full-up” position) and the safety rod is coupled to the rod drive.

These interlocks are controlled by the FCS logic. Figure 7a.3-2 presents a diagram of the safety and control rod control logic and control. This interlock allows for the insertion of negative reactivity by inserting the safety rod if needed during reactor startup. Any of the rods can be driven into the core, adding negative reactivity, at any time without interlock interference. The safety rod remains fully withdrawn during reactor operations.

Rod Position Indication

The rod drive down position and rod drive up position limit switches are mechanically actuated by the drive shaft of the rod drive and are accessed above the pool for maintenance and repair. They are used to set the stroke of the rod drive, indicate the full-up and full-down rod drive positions, stop the rod drive motors when full-up or full-down, and provide limit switch information to the FCS interlock circuits. The rod drive up and rod drive down position indication are provided on the control console.

The rod drive position function indicates precise rod drive position to the operator throughout the full range of motion for each control and safety rod between full-down and full-up positions when coupled to the rod drive magnet.

The rod-coupled limit switches indicates that the connecting rod armature of each control or safety rod is in contact with its rod drive magnet, informing the operator that the rod position corresponds to the rod drive position when the reactor is in operation (not shutdown). The rod-coupled indications provide limit switch information to the FCS control rod withdrawal interlock logic that the safety rod is full-up.

The rod-down limit switches indicate that each safety and control rod is in the fully core-inserted position regardless of rod drive position.

Automatic Power Control Mode

The rod control functionality within the FCS is equipped with an automatic power control feature that automatically maintains the set power level once the reactor has reached the desired steady-state power level and the operator initiates the mode. The system compares reactor power input from a PRNI channel to the input of the rod drive position function and generates a command signal to the control rod drives to either insert or withdraw the control rod bank to maintain the set power level. The automatic reactor power level control feature is intended to be used to maintain power after the operator has established the desired steady-state power.

The automatic power control feature is not intended to be used for large changes in power. An interlock restricts automatically controlling the rod bank position if power is in the upper three (3) decades (power range) and the desired power is within 2 percent of the actual power. If the power level becomes greater than 2 percent of the set power level the feature disengages, returning power level control to manual mode. This ensures that large changes in power are not made without operator action.

Audible and visual annunciation inform the operator that the automatic control feature has disengaged and that operator intervention is necessary. The control console indicates when the automatic control feature is engaged.

The automatic control feature cannot defeat the protection afforded by rod control interlocks or control rod bank speed limitations so that conditions beyond those analyzed in the applicable accidents analyses are not introduced.

Neutron Source

The reactor system design provides for an external source of neutrons to support monitoring of subcritical multiplication when the intrinsic neutron source level alone is not visible to the operator or the nuclear instruments. The neutron source is remotely positioned in the core region by a drive mechanism as described in Section 4a.2. The position of the source in the core is such that the neutrons emitted from the source detected by the nuclear instrument fission chambers ensure that meaningful indication is available to the RPS and the operator at very low power levels.

The neutron source is attached at the bottom end of the drive. There is no electromagnet coupling or scram function associated with the source drive. Simple pushbutton controls supply the power to the drive motor. The source drive-out and the source drive-in limit switches provide indication when the source drive is at either end of its travel and secure power to the source drive motor at the end of travel. The source drive limit switch status is provided to the OCDS.

7a.3.2.2 Reactor Cooling

The reactor coolant system instrumentation provides continuous monitoring of primary and secondary coolant system parameters necessary for safe reactor operation. These measurements are integrated into the OCDS and provide both indication and alarm functions to alert operators of abnormal conditions. The following section describes each monitored parameter and its function within the I&C architecture.

Bulk Pool Coolant Level

Reactor pool coolant level is continuously monitored to ensure adequate shielding and core cooling capability. The level measurement provides indication on the BOP display and generates alarms if pool level deviates outside the normal operating range. Pool coolant level is also monitored by the RPS with time-delayed scram initiation on low level. The pool level instrumentation interfaces with the primary coolant makeup water system described in Chapter 5 to control automatic makeup water addition and provides interlock functions to prevent overfill conditions.

Bulk Pool Coolant Temperature

Bulk pool coolant temperature is measured to monitor overall thermal conditions in the reactor pool and verify that the primary coolant system is maintaining adequate heat removal. This measurement provides trend information regarding primary coolant system performance and helps operators assess whether cooling system capacity is appropriate for current reactor power levels and environmental conditions. Bulk pool coolant temperature indication and alarms are provided on the OCDS display to alert operators if temperature rises above acceptable limits during reactor operation.

Primary Coolant pH and Conductivity

Primary coolant pH and conductivity are continuously monitored to ensure coolant chemistry remains within specifications necessary to minimize corrosion of reactor components and maintain effective ion exchange system performance. High-purity, deionized coolant is essential for controlling corrosion and capturing radioactive ions in the demineralizer beds. Water quality measurements are displayed on the BOP system and generate alarms if pH or resistivity drift outside acceptable ranges, prompting operators to assess primary coolant cleanup system performance or initiate corrective actions. Meters send the reactor pool coolant pH and conductivity measurements to the OCDS via the FCS to display and alarm if the levels exceed allowable limits.

Primary Coolant Cleanup System Differential Pressure

Differential pressure across the primary coolant cleanup system demineralizer beds is monitored to assess resin bed loading and filter condition. Increasing differential pressure indicates that the demineralizer resin or filters are becoming loaded with captured impurities or particulates and approaching the need for replacement. This measurement is displayed on the OCDS and alarmed when differential pressure reaches levels indicating that resin bed or filter changeout should be scheduled to maintain effective coolant purification capability.

Primary Coolant Pressure

Primary coolant system pressure is monitored on each cooling loop to verify proper pump operation and detect potential leaks or flow restrictions. Pressure measurements provide operators with information necessary to assess primary coolant system integrity and performance. These measurements are displayed on the OCDS and alarmed if pressure deviates significantly from expected values during system operation, which could indicate pump malfunction or piping system degradation.

Heat Exchanger Inlet Temperature

Primary coolant inlet temperature measures the temperature of pool coolant entering the primary coolant system pumps and heat exchangers. This measurement, combined with outlet temperature, allows operators to calculate heat removal rate and verify proper primary coolant system performance. Inlet temperature is displayed on the BOP system and provides baseline data for assessing coolant system thermal performance and detecting gradual changes in heat exchanger effectiveness or cooling capacity.

Heat Exchanger Outlet Temperature

Primary coolant outlet temperature measures the temperature of cooled coolant returning from the heat exchangers to the reactor pool downcomer. This is a critical parameter for reactor operation, as excessively high return temperatures would increase core inlet temperature and potentially challenge fuel thermal limits. Outlet temperature is monitored on the OCDS display with alarm setpoints established to ensure return coolant temperature remains within acceptable limits for continued full-power operation, as specified in Chapter 5.

Heat Exchanger Differential Pressure

Differential pressure between the secondary and primary sides of each heat exchanger is continuously monitored to verify that the secondary system maintains higher pressure than the primary system. This positive differential pressure ensures that any heat exchanger tube leakage results in clean secondary coolant entering the primary system rather than potentially contaminated primary coolant entering the secondary system. Differential pressure is displayed on the OCDS and alarmed if the pressure differential falls below the minimum required value specified in Chapter 5.

Secondary Coolant System Flow Rate

Secondary coolant system flow rate is monitored on each cooling loop to verify proper secondary pump operation and adequate flow through the heat exchangers. Flow rate indication allows operators to detect secondary system pump degradation or flow restrictions that could reduce heat rejection capability. Secondary flow measurements are displayed on the OCDS and alarmed if flow falls below minimum values required to support full-power reactor operation.

Secondary Coolant Inlet and Outlet Temperatures

Secondary coolant temperatures are measured at the cooling tower outlets (heat exchanger inlets) and at the heat exchanger outlets (cooling tower inlets) to assess secondary system heat rejection performance. These measurements allow operators to evaluate cooling tower effectiveness under current environmental conditions and verify that secondary system performance is adequate to maintain primary coolant temperatures within specifications. Temperature measurements are displayed on the OCDS with alarms to alert operators if secondary temperatures indicate degraded cooling capacity.

Secondary Coolant System Pressure

Secondary coolant system pressure is monitored to verify proper pump operation and to ensure that secondary pressure is maintained higher than primary pressure at all times. This positive pressure differential prevents potential transfer of radioactive primary coolant into the secondary

system in the event of heat exchanger tube leakage. Secondary pressure measurements are displayed on the OCDS and alarmed if pressure drops below acceptable values or if the required pressure differential with the primary system is not maintained.

Cooling Tower Water Level

Water level in each cooling tower reservoir is monitored to ensure adequate secondary coolant inventory for continued system operation. Level measurements alert operators to excessive evaporation, drift losses, or bleed-off that requires makeup water addition to the secondary system. Cooling tower coolant levels are displayed on the OCDS and alarmed on low level to prompt operator action before secondary system inventory becomes insufficient for proper pump operation or heat rejection.

Primary and Secondary Coolant Pumps Control

The primary coolant system uses redundant pumps to provide the flow and pressure for the primary side of the cooling system. Only one pump is necessary for cooling during full power reactor operations. Each primary coolant pump is equipped with individual start and stop controls accessible from the control console. Pump control switches are key-locked to prevent inadvertent operation and provide clear indication of pump running status through dedicated indicating lights. Operators can select which pump operates based on operational needs, maintenance schedules, or equipment performance considerations.

Primary Coolant Makeup Water System Controls

The primary coolant makeup water system incorporates both automatic and manual control modes. In automatic mode, the makeup water system initiates coolant addition when reactor pool level drops below a predetermined setpoint and secures when level returns to the normal operating range. Manual controls allow operators to override automatic operation and directly command makeup water addition or secure the system regardless of pool level.

7a.3.2.3 Environment

Reactor Facility High Bay Differential Pressure

The RF high bay differential pressure channel measures and displays the differential pressure of the RF high bay compared to the surrounding areas. A differential pressure transmitter sends the measured value to the OCDS via the FCS to display and alarm if the reactor high bay differential is less than a specified value.

High Bay Exhaust Fan Control

The RF high bay exhaust fans control the flow rate to the RF high bay exhaust stack to maintain a negative pressure in the RF high bay with respect to the rest of the RF and atmosphere. Only one of the dual-redundant fans is necessary to maintain negative pressure during full power reactor operations. Each RF high bay ventilation exhaust fan can be started and stopped from the control console (remote mode) or from the local controller (local mode). The fan motors indicate a status of running or stopped locally and send the status signal to display at the OCDS via the FCS.

7a.3.3 FACILITY CONTROL SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

Table 7a.3-1
FCS Monitored Parameters

Parameter	Interfaces	Range
Linear reactor power	• Linear power display • FCS power level control function • Reactor control display	0% to 200% (minimum)
Control and safety rod drive positions	• FCS • Reactor control display	Full-Up Full-Down Rod Contact 0 – 1000 units
Control and safety rod down	• Limit Switch • Reactor control display	Rod Full-Down
Bulk pool coolant temperature	• FCS • OCDS	0°C to 120°C
Pool coolant conductivity	• FCS • OCDS	Note[(a)]
Pool coolant pH	• FCS • OCDS	Note[(a)]
Primary coolant cleanup system differential pressure	• FCS • OCDS	Note[(a)]
Primary coolant pressure	• FCS • OCDS	Note[(a)]
Heat exchanger inlet and outlet temperatures	• FCS • OCDS	Note[(a)]
Heat exchanger differential pressure	• FCS • OCDS	Note[(a)]
Secondary coolant system flow rate	• FCS • OCDS	Note[(a)]
Secondary coolant inlet and outlet temperatures	• FCS • OCDS	Note[(a)]
Secondary coolant system pressure	• FCS • OCDS	Note[a)]
Cooling tower coolant level	• FCS • OCDS	Note[(a)]
Primary and secondary coolant pumps control	• FCS • OCDS	On/Off
Primary coolant makeup water system controls	• FCS • OCDS	On/Off
High bay exhaust fan control	• FCS • OCDS	On/Off
Reactor high bay differential pressure	• FCS • OCDS	0 – 1 inch water column

a) Value to be determined based on final design calculations; the final setpoint will be documented in the Operating License Application.
Abbreviations: FCS = facility control system | OCDS = operator control and display system | °C = degrees Celsius

Table 7a.3-2
Control and Safety Rod Parameters

Indication	Sensor	Function
Rod drive full-down position	Limit switch	1. Indicates lower end of rod drive travel 2. Secures rod drive motor down power
Rod drive full-up position	Limit switch	1. Indicates lower end of rod drive travel 2. Secures rod drive motor up power
Rod drive Vernier position	Resistive linear transducer	Indicates rod drive Vernier position throughout rod drive stroke
Rod coupled to the rod drive	Limit switch	1. Indicates contact between the rod drive and the rod armature 2. Provides indication the rod position is following rod drive position
Rod down	Limit switch	Indicates rod down
Source out	Limit switch	1. Indicates source out of the core 2. Secures source drive motor out power
Source in	Limit switch	1. Indicates source in the core 2. Secures source drive motor in power

Table 7a.3-3
FCS Accident Mitigative Functions Summary

Parameter	Function	Limit	Chapter 13 Accident Analysis Cross-Reference
Reactivity insertion rate	Limit the maximum speed of all control rods.	Provided in Chapter 14	IER-1 – Ramp insertion of excess reactivity from control rod bank withdrawal

Abbreviations: FCS = facility control system | IER = insertion of excess reactivity

7a.4 REACTOR PROTECTION SYSTEM

The safety-related RPS provides automatic and manual scram functions to protect the target cladding under all credible conditions. Protection is afforded by limiting reactor power level and core temperature to prevent reaching critical heat flux conditions. The RPS also provides indications of reactor power, reactor period, pool coolant level, and core inlet coolant temperature at the control console in the reactor control room. The RPS is a hard-wired analog system that uses integrated circuit logic gates and physical relays and switches to remove power from the safety and control rod drive magnets. The RPS also provides the MPS scram circuit to shut down the reactor.

7a.4.1 REACTOR PROTECTION SYSTEM DESIGN BASES

The RPS performs the following:

- Automatically initiates a reactor scram when any monitored safety parameter exceeds its technical specification limit or setpoint.
- Accomplishes reactor scram by de-energizing the electromagnets that couple the control and safety rod drives to their respective rods, allowing gravity insertion.
- Provides manual scram capability from the reactor control room, accessible to reactor operators at all times when the reactor is not secured.
- Employs 2-out-of-3 coincidence logic for reactor power channels and core inlet temperature channels to minimize spurious scrams while maintaining high reliability of protective action.
- Allows on-line maintenance, testing, and calibration of any single channel while maintaining the minimum number of operable channels required by technical specifications.
- Provides clear annunciation when any channel is bypassed, inoperable, or in a maintenance mode that affects the protection logic.
- Continuously monitors and displays core coolant inlet temperature to detect conditions that could challenge fuel cooling capability.
- Continuously monitors and displays pool coolant level to detect conditions that could challenge fuel cooling capability.
- Continuously monitors source range neutron flux over at least five decades with count rate indication.
- Continuously monitors wide range neutron flux over 10 decades of isolated log power indication.
- Continuously monitors linear power range neutron flux over the upper three decades of the operating range.
- Continuously calculates and indicates reactor period over the entire operating range to detect rapid power excursions.
- Monitors the integrity of high voltage supplies to neutron detectors and initiates appropriate alarms or protective actions upon loss of detector operability.

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- Provides isolated signals to the FCS to enable automatic reactor power control functions without compromising RPS independence.

7a.4.2 REACTOR PROTECTION COMPONENTS AND FUNCTIONS

The RPS monitors wide range reactor power, reactor period, power range linear reactor power, pool coolant level, and core coolant inlet temperature parameters as listed in Table 7a.4-1.

7a.4.2.1 Scram Circuit and Magnet Power Supply

Scram Logic and Actuation

The RPS employs a multi-stage logic architecture to ensure reliable reactor shutdown while minimizing spurious scrams. Each safety channel contains comparator circuits operating in bistable mode that continuously compare measured process variables against established technical specification setpoints. When a measured parameter exceeds its setpoint, the comparator generates a channel trip signal.

Individual channel trip signals are transmitted to the MPS, which performs coincidence logic verification. For parameters employing 2-out-of-3 coincidence logic (reactor power and core inlet temperature), the MPS initiates a scram only when two or more channels indicate a trip condition. This architecture provides protection against spurious scrams from single-channel failures while maintaining high reliability for actual safety challenges.

The pool coolant level channel is the only scram initiating channel that does not employ coincidence voting in the RPS. A single trip signal initiates a scram. This is acceptable because of the slow changing nature of the pool coolant level. Level annunciation at the OCDS and performance of regular maintenance checks ensures that an operator notices significant reduction in pool coolant level days before a critical level is reached.

Once the MPS determines that scram conditions are met, it de-energizes the scram relays. Opening the scram relay contacts interrupts electrical power to both the supply and return legs of the scram bus, ensuring complete de-energization of all control rod and safety rod electromagnets regardless of potential ground faults in the circuit. With electromagnet power removed, the control rods and safety rods fall by gravity into the core, shutting down the reactor.

Figure 7a.4-1 presents a simplified diagram of the MPS and RPS relay logic. The three channels provide trip signals to three independent OR gates within the MPS coincidence logic. When any two of the three period channels indicate a trip condition, the MPS coincidence logic is satisfied and a scram is initiated. Figure 7a.4-2 presents a simplified diagram of the scram relay circuit.

Scram Completion and Reset

The scram actuation latches in the tripped state and cannot be reset until:

a. The initiating trip condition has cleared.
b. The cause has been investigated and corrected.
c. Deliberate operator action is taken to reset the system.

This design ensures that scram actions proceed to completion without the possibility of premature interruption and that reactivity cannot be added until the reactor is in a safe, stable condition.

Fail-Safe Design

All MPS components are designed to fail in the safe (tripped) condition upon loss of power or component failure. The bistable trip circuits generate a trip signal (logic low) when unpowered. Logic gates output a trip condition (logic low) when unpowered. Scram relays de-energize and open scram bus contacts when control power is lost, and relay drivers default to the scram condition when unpowered. This comprehensive fail-safe design ensures that any single power supply failure, component failure, or loss of channel power results in either a reactor scram or placement of the affected channel in a tripped state, maintaining the required coincidence logic with remaining operable channels.

Magnet Power Supply

The MPS is a hardwired, non-programmable system utilizing integrated circuit logic gates for coincidence and logic functions, electromagnetic relays for power interruption and scram bus control, and mechanical switches for manual scram and individual rod control. No software, firmware, or programmable logic controllers are employed in the MPS, eliminating concerns related to software common-cause failures and simplifying the safety analysis and licensing basis.

Dual-Leg Interruption

The scram bus is configured to interrupt both the positive supply and negative return conductors feeding the electromagnets. This dual-leg interruption design provides defense against ground faults that could otherwise create an alternate current path through a grounded magnet coil, potentially preventing scram. Even in the presence of a single ground fault anywhere in the scram bus or magnet circuits, complete de-energization of all electromagnets is ensured.

Rod Drop Testing and Maintenance

The MPS incorporates individual rod drop capability, allowing operators to selectively de-energize any single control or safety rod electromagnet. This feature supports verification of free rod drop during surveillance testing, measurement of individual and integral rod worth using the rod drop method, and maintenance activities requiring rod position changes while the reactor is shutdown. Individual rod drop functions are implemented through dedicated switches and relay logic independent of the automatic scram circuitry.

7a.4.2.2 Safety And Control Rods

One safety and four control rods are available to shutdown core reactivity upon reactor scram. The operation of the reactor control rod drive is described in Section 7a.3. The construction of the safety and control rods is presented in Chapter 4a.

The safety and control rods (rods) are built with a magnet armature attached to the upper end of the connecting rod assembly. If the RPS detects a scram condition, the RPS functions as described above to remove power to the rod drive magnets for the safety rod and the four

control rods. The rods and the rod drive magnets uncouple and the rods fall by gravity to their full-down position. The rods insert negative reactivity sufficient to shut down the reactor.

7a.4.2.3 Manual Scram

Independent manual scram capability is provided through hardwired push-pull scram switches located in the reactor control room. Activation of a manual scram switch directly opens the scram bus through mechanical contacts, bypassing all electronic logic and providing an independent means of reactor shutdown. This manual scram function is available at all times when the reactor is not secured. Manual scram buttons are provided at the MPS panel power disconnect and to the operator on the control console.

7a.4.2.4 Wide Range Nuclear Instruments

A WRNI channel consists of a fission chamber, amplifier, and rack mounted signal processor.

The WRNI measure and display reactor power over 10 decades, providing indication from startup to full power. Reactor power is displayed on a log scale on the WRNI signal processor that covers the entire range of the channel. The WRNI also provides source range indication of count rate if desired. The WRNI circuitry develops these indications from a single fission chamber signal.

The WRNI power signal is input to a comparator circuit where the process variable signal (power or period) is compared to the setpoint level of the comparator. If the setpoint level is exceeded, the comparator circuit shifts the bistable circuit from the reset state to the tripped state. The MPS logic circuits apply coincidence logic to the trip signals. When the coincidence conditions are met, a reactor scram is initiated. When tripped the individual monitoring channels also provide annunciation both locally and on the control console.

The WRNI channels have onboard calibration and test capabilities. The WRNI measuring channels send isolated signals to the OCDS for display on the control console.

Wide Range Channel Trips

The following trip circuits monitor reactor parameters to generate trip voting signals to scram the reactor:

- A period trip calculated to be equal to or less than 5 seconds.
- A loss of high voltage power supply integrity trip scrams the reactor if fission chamber high voltage drops below allowable levels. The level setpoint will be determined in the Operating License Application.

7a.4.2.5 Power Range Nuclear Instruments

A PRNI channel consists of a fission chamber, amplifier, and rack mounted signal processor.

The PRNI measures and displays reactor power as percent power from 0 to 120 percent. This PRNI indication overlaps the WRNI in the upper decades of reactor power. Reactor power is displayed on a linear scale.

The PRNI power signal is input to a comparator circuit where the process variable signal (reactor power) is compared to the setpoint level of the comparator. If the setpoint level is exceeded, the comparator circuit shifts the bistable circuit from the reset state to the tripped state. The MPS logic circuits apply coincidence logic to the trip signals. When the coincidence conditions are met, a reactor scram is initiated. When tripped, the individual monitoring channels provide annunciation both locally and on the control console.

An isolation amplifier provides an isolated analog output of reactor power for use in non-RPS systems and functions such as automatic power control and remote indication. Digital outputs are also supplied for non-RPS or control functions.

The PRNI monitors fission chamber high voltage bias. Bias voltage below the allowable value is alarmed because it can negatively affect the PRNI channel's linearity and therefore its reliability.

The PRNI channels have onboard calibration and test capabilities. The PRNI measuring channels provide isolated signals to the OCDS for indication and alarm.

Power Range Channel Trips

The following trip circuits monitor reactor parameters to generate trip voting signals to scram the reactor:

- A high-power trip scrams the reactor when reactor power exceeds the high-power scram setpoint. The percent power setpoint will be determined in the Operating License Application.
- A loss of high-voltage trip scrams the reactor if fission chamber high voltage drops below allowable levels. The level setpoint will be determined in the Operating License Application.

7a.4.2.6 Core Coolant Inlet Temperature Channel

The RPS monitors core coolant inlet temperature using three independent measurement channels, each consisting of a Type K thermocouple installed in the reactor cooling system downcomer to measure coolant temperature entering the reactor lower plenum. Each channel includes a commercially available signal linearizer, comparator circuit operating in bistable mode, and local display.

The temperature monitoring channels provide continuous indication over a measurement range of -10°C to 120°C (14°F to 248°F). Temperature signals are transmitted via isolated signals to the control console and OCDS for continuous operator monitoring.

Each channel comparator continuously compares the measured temperature against the technical specification setpoint. When the measured temperature exceeds the setpoint, the comparator shifts the associated bistable circuit from the reset state to the tripped state, generating both local and OCDS annunciation. The three core coolant inlet temperature channel trip signals are processed through 2-out-of-3 coincidence logic in the MPS. When any two channels indicate a trip condition, a reactor scram is automatically initiated.

The signal linearizers incorporate upscale burnout protection to ensure fail-safe operation. If a linearizer loses its thermocouple input signal due to an open circuit, short circuit, or thermocouple failure, the linearizer output drives to full scale, causing the affected channel to

trip on high temperature indication. This design ensures that sensor or wiring failures result in conservative protective action rather than loss of protection.

7a.4.2.7 Pool Coolant Level Channel

The RPS monitors reactor pool coolant level using a fluid level sensor installed on the interior pool wall with a measurement range of 0 to 3 meters (m) (0 to 10 feet [ft.]) below floor level. The level channel provides continuous indication locally at the instrument and transmits isolated signals to the control console and OCDS.

The level signal is continuously compared against a setpoint of 1 m (3 ft.) below the normal full pool level. When the measured level drops below this setpoint, the comparator shifts the bistable circuit to the tripped state, initiating both a hardwired alarm on the control console and a time-delay scram timer rather than an immediate reactor scram.

The time-delayed scram response is justified by the inherently slow rate of pool level change in a pool-type research reactor. During the delay period, reactor personnel are required to manually monitor pool level at frequencies specified in the technical specifications. This approach allows operators to investigate the cause, implement corrective actions such as identifying and isolating leaks or adding makeup water, or manually scram the reactor if conditions warrant, before automatic shutdown occurs. If pool level is not restored above the setpoint before the delay timer expires, the RPS automatically initiates a reactor scram.

The pool level measurement channel incorporates fail-safe design such that loss of the sensor signal due to electrical faults or instrument failure is interpreted as a low-level condition, thereby initiating the scram delay timer and ensuring conservative protective action.

7a.4.2.8 Indications

The PRNI measuring channels provide linear indication of reactor power in the power range. The WRNI measuring channels provide indication of log power and reactor period from shutdown power levels to full power operation. The core coolant inlet temperature measuring channels provide indication of core coolant inlet temperature. The pool coolant level measuring channel provides indication of pool coolant level. The PRNI measuring channels, WRNI measuring channels, and core coolant inlet temperature measuring channels ensure that the operator has sufficient information to maintain reactor nuclear parameters at or below the prescribed limits on power, period, and core coolant inlet temperature. These measuring channels are operable when they can measure and display their outputs as described in Subsections 7a.4.2.4 and 7a.4.2.5.

7a.4.2.9 Power Supplies

Each RPS channel is powered by an independent, nonsafety-related power supply to enhance system reliability and maintainability. Isolation transformers are incorporated at each channel power input to:

- Prevent electrical transients in facility power distribution from propagating into RPS channels.
- Maintain electrical independence between redundant channels.
- Facilitate troubleshooting and maintenance activities.

While the channel power supplies are classified as nonsafety-related, their failure modes are bounded by the fail-safe design of downstream RPS components, which default to the tripped condition upon loss of power.

7a.4.3 REACTOR PROTECTION SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

Table 7a.4-1
(Sheet 1 of 2)
Reactor Protection System Instrument Overview

Instrument	Sensor	Process Variable Measured	Control Function	Chapter 13 Accident Analysis Cross-Reference
WRNI (three channels)	Fission chamber	Reactor power Reactor period PS voltage	Signal: • Low power/loss of signal scram • Period scram • Low PS voltage integrity	IER-1 – Ramp insertion of excess reactivity from control rod bank withdrawal IER-2 – Prompt insertion of excess reactivity from activation canister ejection EM-1 – Failure of activation/irradiation canister
PRNI (three channels)	Fission chamber	Reactor power PS voltage	Signal: • Low power/loss of signal scram • High power scram • Low bias voltage annunciation	IER-1 – Ramp insertion of excess reactivity from control rod bank withdrawal
Coolant inlet temperature instrument (three channels)	Thermocouple	Coolant inlet temperature	Signal high core coolant inlet temperature scram	LOC-1 – Partial loss of coolant LOF-1 – Loss of cooling system flow LOF-2 – Loss of cooling system heat sink LOF-3 – Overheating of a target due to flow blockage
Pool coolant level instrument (one channel)	Level transmitter	Pool coolant level	Signal pool low coolant level scram	MHA – Maximum Hypothetical Accident LOC-1 – Partial loss of coolant

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Table 7a.4-1
(Sheet 2 of 2)
Reactor Protection System Instrument Overview

Instrument	Sensor	Process Variable Measured	Control Function	Chapter 13 Accident Analysis Cross-Reference
Manual scram instrument	Pushbutton	Pressed	Scram – De-energize MPS scram circuit	None
MPS	Relay circuit	Instrument scram bistable state (high/low)	Scram – Automatically de-energize safety and control rod electromagnets	LEP-1 – Loss of normal electrical power

Abbreviations: WRNI = wide range nuclear instruments | PS = Power Supply| IER = insertion of excess reactivity | EM = experiment malfunction | PRNI = power range nuclear instruments | LOC = loss of coolant | LOF = loss of coolant flow | MHA = maximum hypothetical accident | MPS = magnet power supply | LEP = loss of normal electrical power

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7a.5 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM

There are no requirements for the I&C system to provide ESF actuation. There are no backup power systems required following reactor shutdown upon a loss of power. Section 4a.3 demonstrates that the reactor pool passively provides the necessary cooling and heat capacity to keep the core cooled to acceptable temperature values following reactor shut down.

7a.6 OPERATOR CONTROL AND DISPLAY SYSTEM

The OCDS is located in the reactor control room adjacent to the RF high bay. All primary reactor operations are performed in the reactor control room. The controls for the OCDS equipment are located primarily on the control console and secondarily at associated instrument racks. The arrangement of instrumentation and displays applies ergonomic principles and provides optimal conditions for assimilation of information.

The OCDS provides two main types of displays – reactor control and BOP. The reactor control display provides the operator with indications from the RPS and FCS related to the operation of the reactor. The BOP display provides indication of the secondary nuclear systems via the FCS. The OCDS is shown in Figure 7a.6-1.

Reactor control and BOP data, including measurements, annunciations, alarms, and scram signals, are digitally recorded and timestamped. The OCDS affords operators the ability to view historical data on a separate display from the operation-critical displays.

7a.6.1 OPERATOR CONTROL AND DISPLAY SYSTEM DESIGN BASES

The OCDS performs the following:

- Provides continuous indication of all safety-significant reactor parameters necessary for reactor operation, including reactor power, reactor period, core coolant inlet temperature, pool coolant level, control rod positions, and scram status.
- Updates displayed parameters at a rate sufficient to provide operators with timely information for safe reactor operation.
- Displays parameters with sufficient accuracy and over appropriate ranges to support operator decision-making during normal operations, anticipated operational occurrences, and accident conditions.
- Incorporates guidance from human factors engineering principles to minimize operator error, including appropriate use of color coding, spatial organization, prioritization of information, and ergonomic considerations.
- Provides reactor protection parameter indications through both digital displays and hardwired panel meters to ensure continued reactor operation capability in the event of digital display system failure.
- Receives safety-related information through isolated outputs to prevent malfunctions or failures in the display system from affecting protection system functions.
- Provides both audible and visual annunciation of RPS trips, alarms, and abnormal conditions to alert operators to conditions requiring attention or action.
- Displays the status of secondary nuclear and facility support equipment necessary for safe and efficient RF operation.
- Provides BOP equipment indications through both digital displays and, for select critical parameters, hardwired panel meters or local indication to ensure continued monitoring capability during digital system failures.
- Provides control functions for BOP equipment through the FCS controller via control console switch panels.

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- Displays radiation monitoring parameters from the RF RMS, including ARM and CAM measurements with associated alarm annunciations.
- Displays radiation monitoring parameters from the HCF, including ARM, CAM, criticality accident alarms, and personnel contamination monitoring data.
- Provides clear indication when the FCS automatic rod control servo is engaged to ensure operator awareness of the reactor control mode.
- Provides clear indication when a channel is bypassed to ensure operator awareness of the system availability.
- Incorporates cybersecurity measures to protect against unauthorized access.

7a.6.2 REACTOR CONTROL DISPLAY AND CONTROLS

The reactor control display shows reactor parameters used to protect and control the reactor, including reactor power, reactor period, core coolant inlet temperatures, pool coolant level, control rod positions, and scram annunciations as listed in Table 7a.6-1. The displays are generated by the OCDS and include both digital displays and hardwired panel meters with indicating lights. The reactor control display provides the nuclear process variable values that operators use to monitor and operate the reactor safely.

RPS instrument measuring channel values and status are supplied to the OCDS via isolated outputs from the instruments themselves. This electrical isolation prevents malfunctions of the display system from affecting the operation of reactor protection. In the event of OCDS digital display failure, all critical indications remain available on the console via hardwired panel meters to allow continued reactor operation. This redundancy in indications ensures operators maintain situational awareness during all reactor operations.

The reactor operation display includes audible and visual annunciation of RPS trips and alarms. The OCDS also displays the status of any RPS or FCS channels that are bypassed for maintenance or testing, providing operators with continuous awareness of system availability and protective function status.

Manual Scram Controls

The control console incorporates redundant manual scram switches that provide direct, hardwired reactor shutdown capability independent of all electronic systems. These mechanical switches are prominently located on the control console for immediate operator access. Manual scram switch position is indicated by both the physical switch position and hardwired indicating lights on the control console.

Control Rod and Safety Rod Position Controls

The control console provides individual control switches for each control rod and safety rod, allowing operators to insert or withdraw rods or drop individual rods on demand. Rod motion control switches are key-locked to prevent inadvertent operation. Each rod control switch operates in spring-return mode for withdrawal and insert commands, requiring continuous operator action to sustain rod motion. A separate latching switch position is provided for individual rod drop functions.

Control rod and safety rod positions are continuously displayed on both digital OCDS displays and hardwired analog panel meters. The analog position indicators are direct outputs from the rod position instrumentation and remain functional independent of OCDS operation. Rod position indications include numerical position values, graphical bar representations showing relative positions of all rods, and limit indication lights showing when rods reach their full-in or full-out positions.

Automatic Reactor Control

Automatic reactor power control is generated by the FCS using isolated input signals from the RPS power-range neutron flux monitoring channels. The OCDS provides clear annunciation on the control console when the automatic mode is engaged, indicating to operators that the reactor is under automatic control rather than manual control.

Automatic control can be disengaged at any time by operator action using the mode select switch, immediately returning the reactor to manual control mode. The automatic control function is nonsafety-related and is isolated from the RPS to ensure that FCS malfunctions cannot prevent reactor shutdown or interfere with protective functions.

7a.6.3 BALANCE OF PLANT DISPLAY AND CONTROLS

The BOP display provides operators with status information for secondary nuclear systems and facility support equipment necessary for safe and efficient RF operation as listed in Table 7a.6-2. Various reactor support systems supply operational data to the OCDS, which generates integrated BOP displays on the control console. These displays include both digital OCDS-generated screens and hardwired analog panel meters with indicating lights for critical BOP parameters requiring dedicated console indication.

The BOP display incorporates audible and visual annunciation for abnormal conditions detected by BOP instruments and systems, alerting operators to equipment malfunctions or parameter deviations requiring attention. Alarm conditions are annunciated both through the OCDS digital display system and, for select critical parameters, through hardwired alarm panels on the control console.

In the event of OCDS digital equipment failure, redundant indication pathways ensure continued reactor operation capability. Select BOP indications are also provided via local indication at the measuring instruments and equipment control panels throughout the facility. This design provides operators with redundancy during all reactor operations and ensures that OCDS failure does not prevent safe reactor operation or orderly shutdown.

BOP Equipment Control Functions

Control functions for BOP equipment are provided through switch panels on the control console. These control switches interface with the FCS controller, which executes the commanded equipment operations. The FCS controller is a commercially available industrial control system widely deployed in nuclear facilities, selected for its proven reliability and extensive operational history in safety-related applications.

Certain BOP systems provide data directly to both the OCDS for operator display and to the FCS for automatic control or monitoring functions. For example, radiation monitoring equipment transmits measurement data to both display and control systems to support operator awareness

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and automated responses to abnormal radiation conditions. This integration ensures coordinated facility response while maintaining appropriate separation between safety-related reactor protection functions and nonsafety-related facility control systems.

7a.6.4 RADIATION MONITORING SYSTEM DISPLAY

The RF RMS is described in detail in Section 7a.7. The RMS includes ARMs and CAMs strategically located throughout the RF to detect and measure radiation levels and airborne radioactivity concentrations. Measured values from these instruments are transmitted to the OCDS for continuous display on the control console and for alarm annunciation when radiation levels exceed established setpoints.

Each ARM and CAM incorporates local indication and alarm capability independent of the OCDS. Local radiation level displays and both audible and visual alarms at each monitoring station provide immediate notification to personnel in the affected area when abnormal radiation conditions are detected. This redundant alarming ensures that facility personnel receive timely warning regardless of OCDS operational status.

Hot Cell Facility Radiation Monitoring Integration

The reactor control room OCDS also displays radiation monitoring parameters from the associated HCF to provide operators with comprehensive radiological awareness across both facilities. Integrated HCF radiation monitoring parameters include ARMs, CAMs, criticality accident alarm system status, and personnel contamination monitoring equipment status and measured values.

The OCDS receives HCF radiation monitoring data via network communications through a dedicated network switch located at the HCF. This data communication link provides real-time radiological status information to RF operators, enabling coordinated facility response to abnormal radiological conditions. The network architecture maintains appropriate isolation between RF safety systems and the HCF data communication systems to ensure that network communication failures or cybersecurity events affecting the HCF cannot impact RPS functions.

Loss of communication between the HCF and RF OCDS is annunciated on the control console, alerting operators that HCF radiation monitoring data is unavailable. During communication outages, HCF radiation monitoring continues to function locally with independent alarm capability at the HCF control stations.

7a.6.5 OPERATOR CONTROL AND DISPLAY SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

Table 7a.6-1
Reactor Control and Display Summary

Parameter	Indication/Control	Source
Wide range reactor power	Indication	Neutron flux monitor channel
Power range reactor power	Indication	Neutron flux monitor channel
Reactor period (rate of change of power)	Indication	Neutron flux monitor channel
Core coolant inlet temperature	Indication	Reactor Protection System
Pool coolant level	Indication	Reactor Protection System
Safety and control rods position	Indication & Control	Control Rod Drive Mechanism
Reactor scram	Indication	Reactor Protection System

Table 7a.6-2
BOP Control and Display Summary

Process Variable/Instrument	Indication/Control	Source
Bulk pool coolant temperature	Indication	FCS
Pool coolant conductivity	Indication	FCS
Pool coolant pH	Indication	FCS
Cleanup loop pumps (on/off)	Indication & Control	FCS
Primary system flow rate	Indication	FCS
Secondary system flow rate	Indication	FCS
Primary system pressure	Indication	FCS
Secondary system pressure	Indication	FCS
Secondary system bulk coolant resistivity	Indication	FCS
High bay exhaust fans (on/off)	Indication & Control	FCS
Primary coolant pumps (on/off)	Indication & Control	FCS
Secondary coolant pumps (on/off)	Indication & Control	FCS
Heat exchanger inlet temperature (primary and secondary coolant)	Indication	FCS
Heat exchanger outlet temperature (primary and secondary coolant)	Indication	FCS
Water level in cooling tower reservoir	Indication	FCS
RF Sump water level and pump (on/off)	Indication & Control	FCS
High bay differential pressure	Indication	FCS
ARMs/CAMs	Indication	RMS

Abbreviations: BOP = balance of plant | FCS = facility control system | ARM = area radiation monitor | CAM = continuous air monitor | RMS = radiation monitoring system

7a.7 RADIATION MONITORING SYSTEM

The Radiation Protection Program requires various portable instruments and personnel monitors as well as passive detectors located throughout the facility non-radiological areas, both inside and outdoors. This section is limited to the permanently installed instrumentation used to provide continuous monitoring of radiation levels in the RF.

Table 7a.7-1 lists the primary RMS parameters.

7a.7.1 RADIATION MONITORING SYSTEM DESIGN BASES

The RMS performs the following:

- Continuous monitoring of area radiation levels at the reactor pool, RF high bay, and RF storage equipment room 1 and indication locally and at the control console.
- Continuous air sampling in the RF high bay and the RF exhaust stack and indication locally and at the control console.
- Annunciation locally and at the control console of elevated levels of airborne or general area radiation.

7a.7.2 RADIATION MONITORING COMPONENTS AND FUNCTIONS

The RMS provides continuous monitoring of radiation levels and airborne radioactivity throughout the RF to protect personnel, detect abnormal radiological conditions, and demonstrate compliance with regulatory dose limits. The RMS consists of fixed monitoring equipment strategically located throughout the facility and portable radiation detection instruments used by radiation protection personnel for surveys and routine monitoring activities.

7a.7.2.1 Fixed Radiation Monitoring Equipment

The fixed equipment used for monitoring radiation consists of two types of systems: 1) the ARM system, used to monitor the level of direct gamma radiation exposure, and 2) the CAM system, used to monitor gross alpha and beta airborne activity. The ARMs and CAMs are commercially available and previously approved for non-power reactor facility use. They have shown acceptable performance throughout the nuclear industry. The ARMs and CAMs provide indication of radiation and contamination levels at the location of the instrument and on the control console BOP display. The ARMs and CAMs also provide annunciation at the location of the instrument and on the control console. This system provides timely indication of area radiation levels around the reactor pool and RF high bay and airborne radiation levels in the RF high bay atmosphere and the effluent air in the RF high bay exhaust stack, allowing for corrective actions by the operator.

Reactor Pool Area Radiation Monitoring

An ARM is installed in the reactor high bay to continuously measure gamma radiation exposure rates in the vicinity of the reactor pool. This ARM is strategically positioned to detect elevated radiation levels that could result from loss of pool coolant shielding, fission product release from irradiated targets or fuel, unexpected increases in reactor power level, or radiation streaming from pool penetrations or experimental facilities.

The reactor pool ARM alarm setpoint is established slightly above the maximum radiation levels normally observed during full-power steady-state reactor operation. This setpoint provides early detection of abnormal conditions while minimizing spurious alarms during normal operations. Activation of the reactor pool ARM alarm alerts operators to investigate the cause and implement appropriate corrective actions, which may include reactor power reduction, evacuation of the high bay area, or reactor shutdown depending on the magnitude and trend of the radiation level increase.

Reactor Cooling System Area Radiation Monitoring

A dedicated ARM is installed in the reactor cooling system equipment room to detect radioactivity in the reactor pool coolant circulating through the primary cooling system and coolant purification loop. This ARM operates in an area with significantly lower background radiation levels compared to the reactor pool area, enabling detection of small increases in pool coolant activity that might not be readily apparent on the reactor pool ARM.

Elevated readings on the cooling system ARM can indicate fuel or target cladding defects allowing fission product leakage into the pool coolant, activation of impurities or corrosion products in the coolant, or contamination from experimental facilities. Early detection of coolant activity increases allows operators to identify and address the source before significant contamination accumulates in the primary system.

Continuous Air Monitoring

CAMs sample airborne effluents in the RF high bay and in the facility exhaust stack to detect and quantify radioactive material releases. The CAMs are equipped to detect radioactive noble gases, radioactive iodine species, and particulate radioactivity (gross alpha and beta activity).

The high bay CAM continuously samples air from the occupied RF areas, providing early warning of airborne contamination that could result in personnel exposure. The exhaust stack CAM monitors facility gaseous and particulate effluent releases to the environment, demonstrating compliance with regulatory release limits and providing data for off-site dose calculations.

Portable Radiation Detection Instruments

The facility maintains an inventory of calibrated portable radiation detection instruments capable of measuring gross alpha, beta, gamma, and neutron radiation. These portable instruments are used routinely by radiation protection personnel to conduct area radiation surveys, monitor radiation levels during maintenance and experimental operations, verify ARM and CAM readings, survey personnel and equipment for contamination, and monitor the movement of radioactive materials within and outside the facility.

Portable instrument types include ion chamber survey meters for measuring gamma exposure rates, Geiger-Mueller detectors for detecting beta-gamma contamination, alpha scintillation detectors for measuring surface alpha contamination, and neutron survey instruments for measuring neutron dose equivalent rates. The portable instrument inventory and calibration records are maintained by the Radiation Protection Program as described in Chapter 11.

7a.7.3 RADIATION MONITORING SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

Table 7a.7-1
Radiation Monitoring Measuring and Alarm Channels

Type	Location	Range	Alarm
ARM – General area radiation	RF high bay	0.01 – 1000 mrem/hr	5 mrem/hr
ARM – General area radiation	Reactor pool	0.01 – 1000 mrem/hr	50 mrem/hr
ARM – General area radiation	Exhaust stack	0.01 – 1000 mrem/hr	5 mrem/hr
ARM – General area radiation	Cleanup loop	0.01 – 1000 mrem/hr	5 mrem/hr
CAM – Airborne radiation (particulate/ noble gas)	RF high bay	Note[a]	Note[a]
CAM – Airborne radiation (particulate/ noble gas)	Reactor pool	Note[a]	Note[a]
CAM – Airborne radiation (particulate/ noble gas)	Exhaust stack	Note[a]	Note[a]

a) Value to be determined based on final design calculations; the final setpoint will be documented in the Operating License Application.
Abbreviations: ARM = area radiation monitor | RF = Reactor Facility | mrem/hr = millrem per hour | CAM = continuous air monitor

7a.8 REFERENCES

ANSI/ANS-15.15, 1986. Criteria for the Reactor Safety Systems of Research Reactors, ANSI/ANS-15.15-1978 (R1986), American National Standards Institute, American Nuclear Society, approved 1978, reaffirmed 1986.

Figure 7a.1-1
Instrumentation and Control One-Line Block Diagram

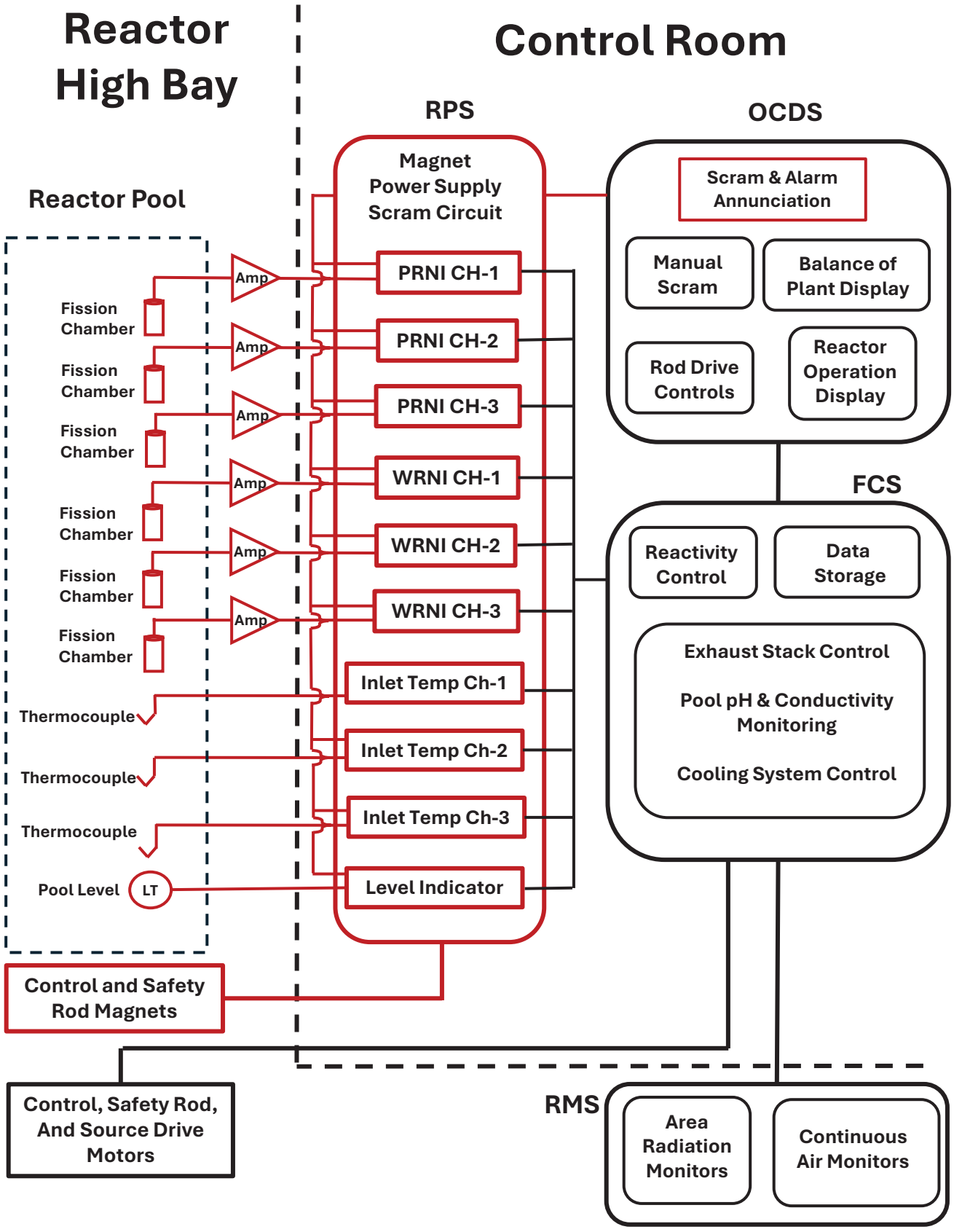

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Figure 7a.3-1
Control/Safety Rod Drive

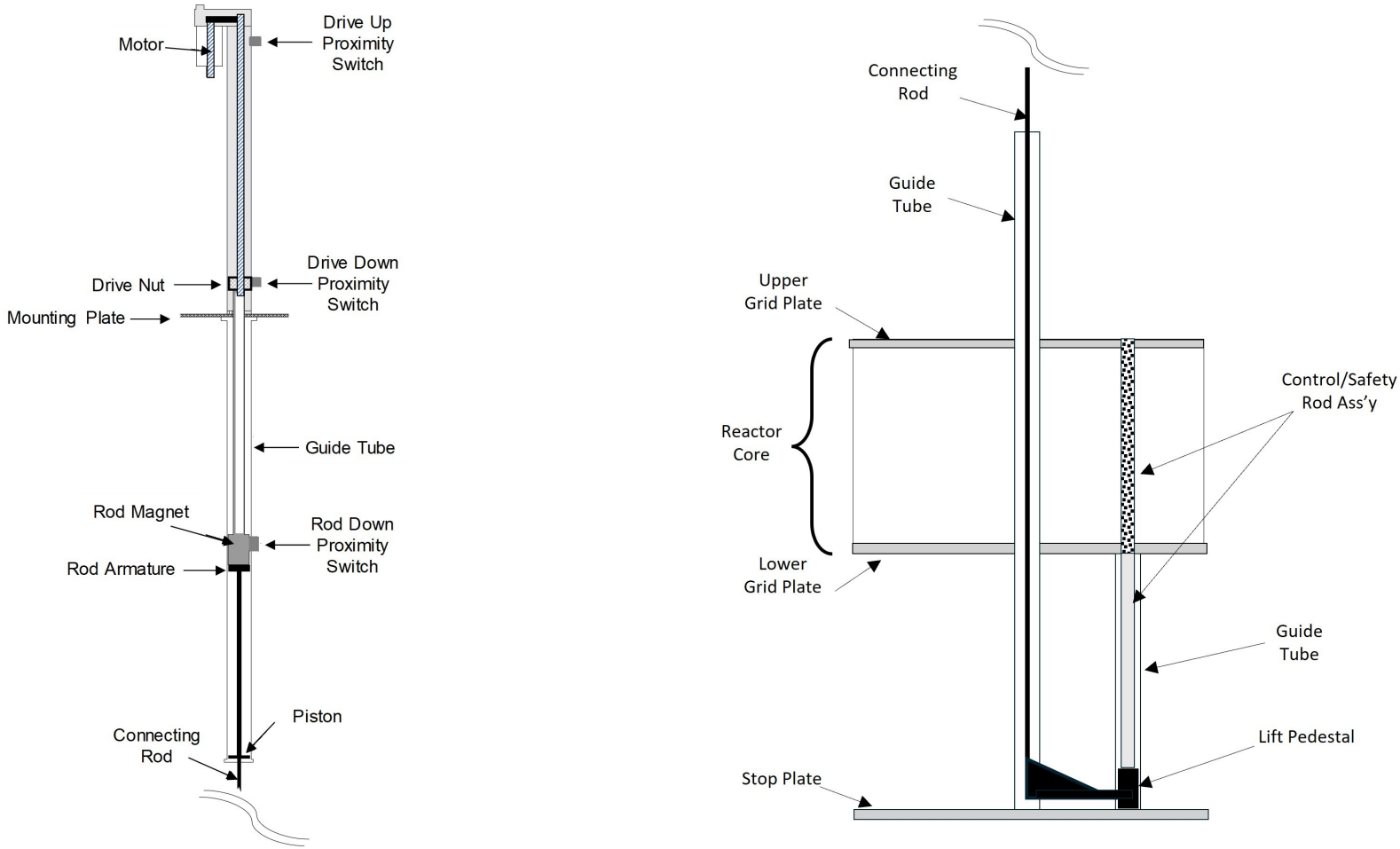


Figure 7a.3-2
Safety and Control Rod Logic and Control

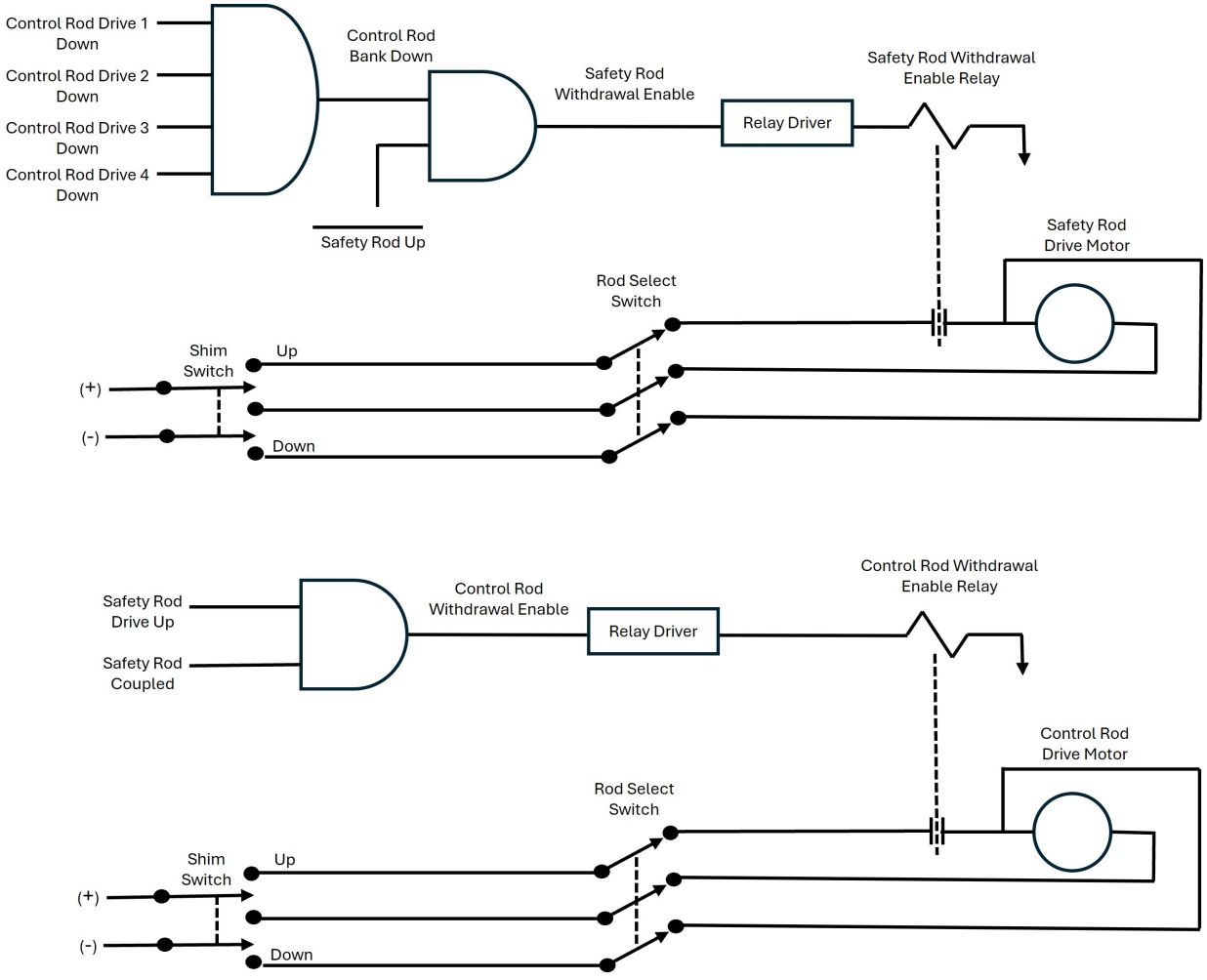


Figure 7a.4-1
2-out-of-3 Voting Logic Diagram

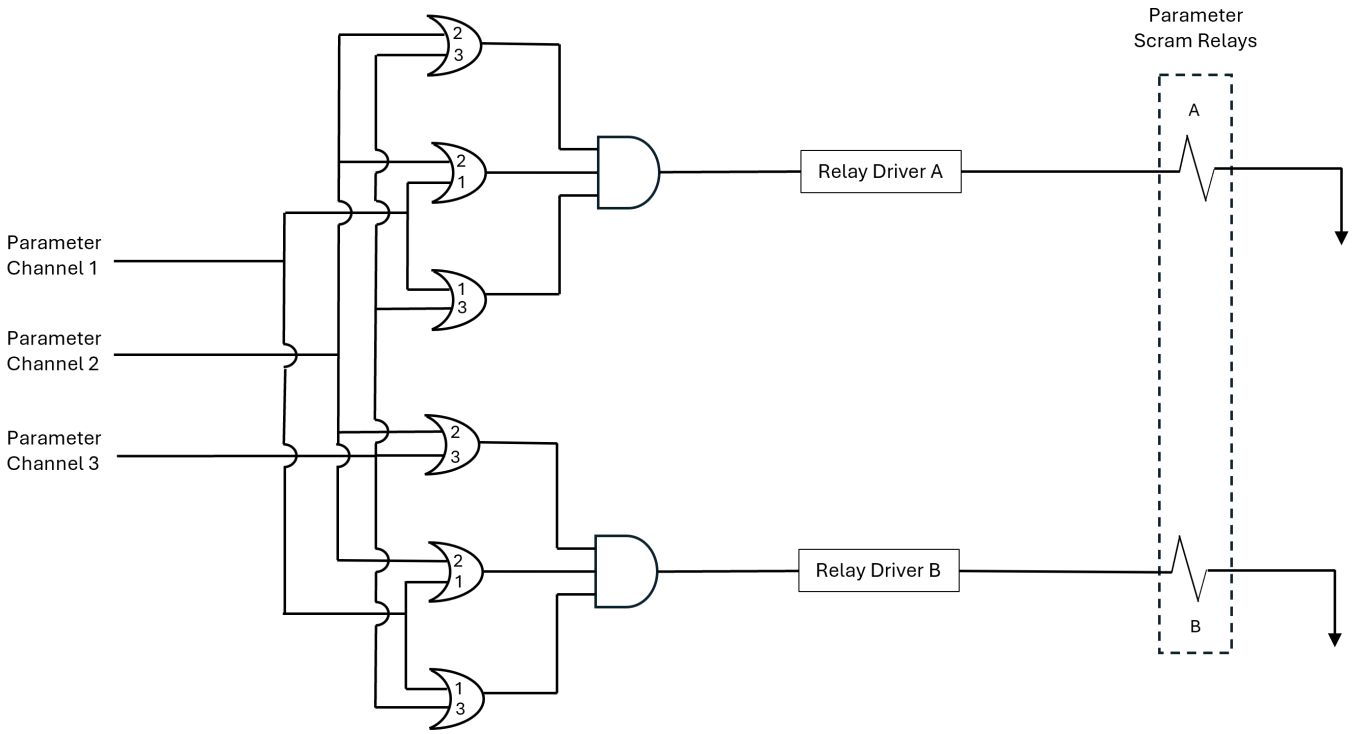


Figure 7a.4-2
Scram Relay Circuit Diagram

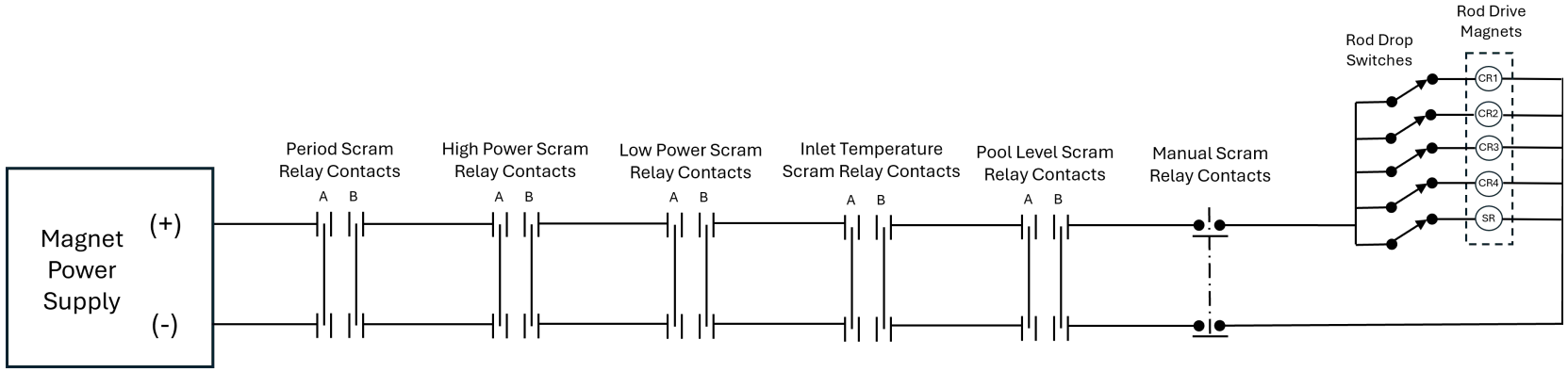
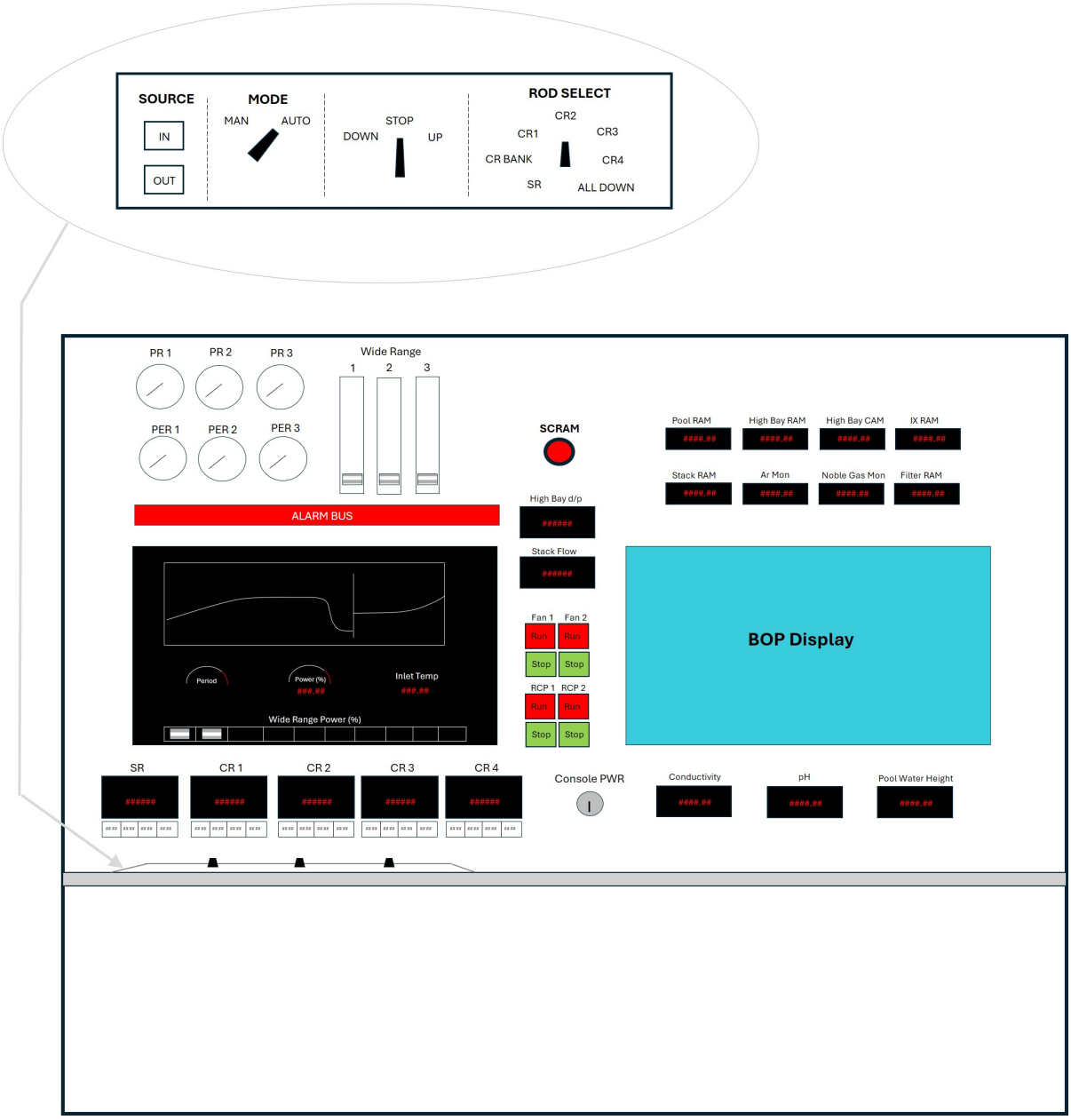


Figure 7a.6-1
Operator Control and Display System



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Preliminary Safety Analysis Report

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Chapter 7b
Hot Cell Facility Instrumentation and Control Systems

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CHAPTER 7b

HOT CELL FACILITY INSTRUMENTATION AND CONTROL SYSTEMS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ANS	American Nuclear Society
ANSI	American National Standards Institute
ARM	area radiation monitor
BAS	building automation system
CAAS	criticality accident alarm system
CAM	continuous air monitor
DC	design criteria
EMIF	Eden Medical Isotope Facility
ESF	engineered safety features
HCF	Hot Cell Facility
HMI	human-machine interface
HPU	hydraulic power unit
I&C	instrumentation and control
IEC	International Electrotechnical Commission
I/O	input/output
LCO	limiting condition(s) for operation
OCDS	operator control and display system
OIT	operator interface terminal
PCM	personnel contamination monitoring
PLC	programmable logic controller
RF	Reactor Facility
RMS	radiation monitoring system
SCB	steel confinement box

Acronym/Abbreviation	Definition
SSC	system(s), structure(s), and component(s)
UPSS	uninterruptible power supply system
UREX	uranium extraction
U.S.	United States

7b Hot Cell Facility Instrumentation and Control Systems

7b.1 SUMMARY DESCRIPTION

The Hot Cell Facility (HCF) is a part of the Eden Medical Isotope Facility (EMIF) within the Eden Isotope Production Complex. Targets irradiated in the reactor are processed in the HCF target processing canyon to extract commercially valuable isotopes. The HCF target processing canyon contains 19 individual steel confinement boxes (SCBs) that house the processing equipment necessary for target processing, product purification, and product packaging for shipment. Waste packaging is also performed and controlled within the SCBs. Additionally, uranium that is recovered is processed for reuse in the fabrication of fresh targets in the target fabrication area of the HCF.

The HCF control system monitors and controls all the HCF systems. These systems within the HCF are the SCB processes, canyon shield doors, elevators, conveyors, cranes, stack monitoring, radiation monitoring system (RMS), criticality accident alarm system (CAAS), and hydraulic power unit (HPU).

The HCF ventilation control system monitors and controls all the HCF ventilation equipment, such as the fans, pumps, and valves, and maintains the pressure differentials between the various HCF ventilation zones.

Both the HCF control system and HCF ventilation control system have local monitoring and control from the HCF mechanical equipment room. Both systems are remotely monitored from the Reactor Facility (RF) operator control and display system (OCDS) as described in Chapter 7a.

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7b.2 DESIGN OF THE INSTRUMENTATION AND CONTROL SYSTEMS

The HCF control system and HCF ventilation control system are designed to meet the requirements established by the design criteria and associated design basis and guidelines.

7b.2.1 DESIGN CRITERIA

The HCF control system monitors and controls subsystems such as the SCB processes, canyon shield doors, elevators, conveyors, cranes, stack monitoring, RMS, CAAS, and HPU. This provides personnel safety and continuity of operations to support isotope production. The HCF control system provides control, measurement, display, annunciation, and monitoring of HCF process systems important to the operation of the facility. The HCF control system components are located in the HCF mechanical equipment room.

The instrumentation and control (I&C) systems important to safe operations are identified in Table 7b.2-1. The HCF control system design requirements have been derived from the credited controls applied in the accident analysis (see Chapter 13b). Defense in depth is applied beyond the credited controls to allow indication of abnormal conditions before limiting conditions for operations (LCOs) are challenged (see Chapter 14b).

The HCF ventilation control system field equipment and instrumentation are monitored and controlled via a centralized HCF building automation system (BAS). The HCF ventilation control system has local monitoring in the HCF mechanical equipment room and is also remotely monitored in the reactor control room from the OCDS. Differential pressure transducers monitor the HCF exhaust filter and HCF exhaust stack fan differential pressures. A flow transducer in the exhaust plenum measures the system exhaust flow. These pressure and flow signals are wired to input/output (I/O) modules that are part of the BAS system, composed of a processor, I/O modules, power supplies, and communications. The chilled coolant system is equipped with flow, pressure, and temperature sensors in the piping, which monitor the chilled coolant being sent to and returning from the air handling units to maintain HCF ventilation zone temperatures. These flow, pressure, and temperature signals are also wired to the I/O modules in the BAS. The BAS hardware components are in the HCF mechanical equipment room.

The following design criteria (DC), addressed in Chapter 3, Table 3.1-1, apply to the design of the HCF control system:

- DC 8, Instrumentation and Controls: The design provides for inclusion of instrumentation and control systems to monitor and control the behavior of safety-related structures, systems and components. Table 3.5-1b of Chapter 3 lists this DC for HCF Zone 1a and uninterruptible power supply system (UPSS) servicing ventilation HCF Zone 1a.
- DC 21, Monitoring Radioactivity Releases: The design provides for monitoring the HCF atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operations, anticipated operational occurrences, and accident conditions.

7b.2.2 DESIGN-BASIS REQUIREMENTS

The primary design basis of the HCF control system is providing radiation protection for the public, workers, and the environment. The secondary function of the HCF control system is to

provide meaningful indications to the operators to support HCF target processing and waste handling and provide annunciation of abnormal conditions.

The HCF ventilation control system monitors the HCF ventilation system and mechanical utility systems. The HCF ventilation control system primary functions are to monitor the HCF ventilation system and monitor and control (turn on and off) the mechanical utility systems.

Cybersecurity measures are provided to protect against unauthorized access where necessary. The network architecture maintains appropriate isolation between RF safety systems and the HCF data communication systems to ensure that network communication failures or cybersecurity events affecting the HCF cannot impact reactor protection system functions. The HCF control system is designed to the following relevant codes and standards and United States (U.S.) Nuclear Regulatory Commission guidance. These standards were uniquely developed for non-power reactors and may contain sections and requirements that do not apply to a particular situation.

- American National Standards Institute/American Nuclear Society (ANSI/ANS) Standard 15.15-1978, Criteria for the Reactor Safety Systems of Research Reactors (R1986) (ANSI/ANS, 1986).
- NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content.
- Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors.

Codes and standards will be further expanded upon and provided with the application for the Operating License.

7b.2.3 SYSTEM DESCRIPTION

7b.2.3.1 HCF Control System

The HCF control system is a centralized control system located in the HCF mechanical equipment room to which all the field instrumentation from the HCF is wired for monitoring and archiving. The HCF control system consists of a programmable logic controller (PLC) processor, I/O modules, communications components, human-machine interface (HMI), and power equipment. The HCF control system is integrated with the RF OCDS. This connection allows the OCDS to remotely monitor the HCF control system. One HMI in the HCF mechanical equipment room allows local monitoring of the HCF control systems.

The HCF control system is responsible for monitoring the HCF atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Operations in the HCF are performed manually. Permissives and interlocks are provided to automatically stop operations, when necessary. Annunciation is employed by the control system and RMS to alert the operators to potential problems. The operator can then correct the condition or perform the actions of LCOs when applicable. The HCF control system is located in

an HCF Zone 3 area to allow easy access and the ability to monitor. Reference Figure 7b.2-1 for the HCF I&C Block Diagram.

The HCF control system monitors and controls the balance of the HCF. This includes:

- RMS: Area radiation monitors (ARMs), continuous air monitors (CAMs), and personnel contamination monitoring (PCM).
- CAAS.
- Localized SCB processing control systems.
- Localized HCF canyon shield door operations.
- Localized transfer systems (transfer canal elevator, HCF material transfer, HCF drum cart transfer, and HCF canyon elevator).
- Localized waste storage canyon waste drum transport and control system.
- Localized waste storage canyon cask loading system.
- Localized HCF crane systems.
- Stack monitoring system.
- HPU.

7b.2.3.2 HCF Ventilation Control System

The HCF ventilation control system is comprised of a centralized BAS control system. The primary purpose of the BAS is to monitor and control the air balance of the HCF ventilation system for HCF Zones 1a, 1b, 1c, 1d, 2, 3, and 4. These HCF Zones have their own individual systems within the BAS for monitoring and control. Reference Figure 7b.3-1 for the HCF ventilation zones block diagram. HCF Zone 1a is the only safety-related portion of the HCF ventilation system, as described in Chapter 6b and 13b.

In the case of an event or loss of off-site power to the HCF, safety-related power is provided to the HCF Zone 1a ventilation equipment by the UPSS, as addressed in Chapters 6b, 8, and 13b.

The HCF ventilation control system monitors the differential pressure between HCF Zone 1a and Zone 2 to ensure HCF Zone 1a is maintained at a negative pressure with respect to Zone 2.

HCF structures, systems, and components (SSCs) provide mitigation functions as described in Chapter 13b and are cross-referenced to HCF accidents shown in Table 7b.2-2.

7b.2.4 SYSTEM PERFORMANCE ANALYSIS

The HCF control system monitors and/or controls the processes to ensure the HCF operates as described in Chapters 4b, 6b, and 9b. The HCF control system responds to conditions to ensure adequate protection is maintained. The HCF control system provides localized control and monitoring status using PLCs that allow monitoring of the identified processes within HCF.

The equipment and operating principles incorporated in the design of the control systems have been chosen to provide a reliable control system that performs as described under all credible environmental HCF system conditions.

7b.2.5 HCF INSTRUMENTATION AND CONTROL SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

7b.2.6 CONCLUSION

The design of the HCF control system is specific to the radiological hazards present within the HCF. The simple but robust HCF control system design is suitable to fulfill the requirements of the design basis.

Table 7b.2-1
I&C Systems Important to Safe Operations

System/Equipment	Function
Ventilation system instrumentation	Ensure proper pressure gradient throughout the HCF
RMS	Provide indication of general area and airborne radiation levels in the HCF and exhaust stack monitoring, and provide local and remote alarms to the OCDS

Abbreviations: I&C = instrumentation and control | HCF = Hot Cell Facility | RMS = radiation monitoring system | OCDS = operator control and display system

Table 7b.2-2
Accident Mitigative Functions Summary

SSCs	Function	Limit	Ch. 13 Accident Analysis Cross-Reference
HCF ventilation system Zone 1a	Mitigates the release of radioisotopes using filters and exhaust through the Zone 1a stack to the environment	(a)	Sections 13b.2.3.1 –13b.2.3.6 Events – DB-FI-001, DB-EE-001, FG-NP-001, DB-RS-003, DB-RS-004, FG-RS-001, DB-RS-005, DB-FI-003, UP-FI-001
CAAS	CAAS is provided in the following areas, providing worker safety defense-in-depth when fissile material is present: • Target processing canyon • Waste storage canyon • SNM storage area • Target fabrication area	(b)	Section 13b.2.3.7 Events – DB-NC-001, UP-NC-001, WX-NC-001, SNMS-NC-001, SNMB-NC-001, OMR-NC-001, IFP-NC-001, FTP-NC-001

a) Provided during the Operating License Application. Note: HCF ventilation system Zone 1a is required to be operating during the dissolution process (SCBs 2-7).
b) Provided during the Operating License Application. Note: Criticality accidents are prevented by engineered and administrative controls placed on SNM mass and volume limitations throughout the HCF. CAAS must be operable when fissile material is present in the worker and storage areas involving SNM usage, transfer, or storage.
Abbreviations: SSCs = structures, systems, or components | HCF = Hot Cell Facility | SCB = steel confinement box | DB = dissolver box | FI = fire | EE = external events | FG = fission gas delay system | NP = natural phenomena | RS = releases/spill | NC = nuclear criticality | UP = uranium extraction process box | WX = waste cask loading bay | SNMS = special nuclear material storage area | SNMB = SNM blending area | OMR = oxide to metal reduction area | IFP = ingot to foil production; | FTP = foil to target production area | CAAS = criticality accident alarm system

7b.3 HOT CELL FACILITY PROCESS CONTROL SYSTEMS

The following HCF systems contain instrumentation used to monitor and control the mechanical process systems located in the HCF.

- Transfer canal elevator system control.
- SCB processing system controls.
- HCF material transfer system control.
- SCB box-to-box material handling system control.
- HCF canyon shield doors system control.
- HCF drum cart transfer system controls.
- HCF canyon elevator system controls.
- Waste storage canyon waste drum transport and control system control.
- Waste storage canyon cask loading systems control.
- HCF crane systems controls.
- HCF stack monitoring control systems.
- Ventilation systems control.
- HPU.

7b.3.1 TRANSFER CANAL ELEVATOR SYSTEM CONTROL

As described in Chapter 1, the HCF portion of the EMIF operates independently from the RF. The transfer canal, a wall separating the facilities, and some utilities are common to both facilities. After irradiation, targets are transferred underwater in the transfer canal from the RF to the HCF target processing canyon for processing. The irradiated target transfer basket is raised into the target receipt box from the transfer canal via the transfer canal elevator system.

The I&C associated with the transfer canal elevator consist of a local control panel that allows the operator to raise and lower the transfer canal elevator using local switches. Position monitoring instruments associated with the transfer canal elevator are located externally of the transfer canal. These instruments are wired to the local control panel where they provide interlocks with the transfer canal system and HCF material transfer system. Signals from the transfer canal elevator local control panel are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

7b.3.2 SCB PROCESSING SYSTEM CONTROLS

As shown on Figure 4b.1-1, a total of 19 SCBs are associated with the target processing canyon, including one target receipt box, four dissolver boxes, five purification boxes, four packaging boxes, two research and development processing boxes, two uranium extraction (UREX) boxes, and one waste packaging box. The activities that occur in each SCB are described in Chapter 4b.

Each SCB has its own operator interface terminal (OIT) located next to the viewing window for the SCB. The OIT displays key parameters such as internal temperature and differential pressure of the SCB to the operator. In addition to monitoring the SCB, the OIT displays values from the RMS and all interlocks and alarms for the HCF. All instrumentation associated with each SCB process is wired back to a local control panel. The local control panel is hardwired using switches and relays to allow the operator to control the HCF material transfer system and any other components deemed necessary to perform process operations.

Signals from the SCB local control panels are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

The following DC apply to the design of this system:

- DC 17, Chemical Protection: The design of the SCB processing system controls ensures there is adequate protection against facility conditions and chemical risks from licensed material and hazardous chemicals produced from licensed material.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The design of the SCB processing system controls provides means to suitably control the release of radioactive material in gaseous and liquid effluents during normal operation, anticipated operational occurrences, and accident conditions.

7b.3.3 SCB MATERIAL TRANSFER SYSTEM POSITION CONTROLS

The SCB material transfer system enables the movement of hardware and material from any SCB to any other SCB using a magnetically coupled rail system. This SCB material transfer system has instrumentation located outside the target processing canyon that monitors the position of the cart on the conveyor system. The instrumentation is located outside of high radiation areas and allows easy access. A local control panel is used for positioning the cart in front of any of the 19 SCBs.

Signals from the SCB material transfer system local control panels are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

7b.3.4 SCB MATERIAL TRANSFER SYSTEM ACCESS CONTROL

The only I&C associated with the SCB material transfer system or pass through handling operations are those needed to monitor the open or closed status of SCB doors for ventilation control. Signals from each of the SCB door position switches are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

7b.3.5 HCF CANYON SHIELD DOORS SYSTEM CONTROL

Two hydraulically operated shield doors are used to allow clean and empty waste drums and carts to enter the HCF target processing canyon. The HCF canyon shield doors are raised and lowered by an HPU. The HCF canyon shield doors have a local control panel consisting of switches and relays needed for operation. Two interlocks are associated with the shield doors.

The first interlock allows only one shield door to be opened at a time to prevent radiation exposure to personnel. The position switches for the HCF canyon shield doors are wired to the

local control panel. Within the local control panel hard-wired interlocks prevent both doors from being open at the same time. Both doors can be closed at the same time.

Figure 7b.3-2 shows the HCF canyon shield doors interlock logic.

The second interlock monitors the pressure differential between the target processing canyon (HCF Zone 2) and HCF Zone 3 outside the shield doors using a differential pressure transmitter. The target processing canyon ventilation must maintain a slightly negative pressure in relation to HCF Zone 3. A PLC triggers an alarm if the pressure differential is not maintained within acceptable limits and a set of contacts interlocks the local controls for the shield doors to prevent opening. Signals from the shield door local control panel are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

The following DC apply to the design of this system:

- DC 8, Instrumentation and Controls: The design of the canyon shield doors system control system provides for the inclusion of instrumentation and controls to monitor and control via interlocks for position and differential pressure to ensure personnel safety and confinement boundaries.
- DC 10, Confinement: The design of the canyon shield doors system control ensures confinement boundaries are maintained and low-leakage barriers are established against uncontrolled releases of radioactivity to the rest of the facility via maintenance of pressure differentials between zones.
- DC 23, Biological Shielding: The design of the canyon shield doors system control ensures adequate protection to the workers from unacceptable levels of radiation during normal operation, anticipated operational occurrences, and accident conditions.

7b.3.6 HCF TARGET PROCESSING CANYON DRUM CART TRANSFER SYSTEM CONTROLS

The HCF drum cart transfer system has a local control panel that allows the operator to control the HCF drum cart transfer conveyor system in forward or reverse. The transfer conveyor system moves the waste drums from SCB 9 to HCF canyon elevator A or B. Interlocks between the drum cart transfer system and the HCF canyon elevators ensure that the drum cart does not interfere with the HCF canyon elevator operation. Signals from the HCF drum cart transfer system local control panel are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

7b.3.7 HCF CANYON ELEVATORS SYSTEM CONTROLS

The instrumentation and controls associated with the HCF canyon elevators (A or B) consist of a local control panel that allows the operator to raise and lower the elevator using switches and position monitoring instruments. The instrumentation is located outside the waste storage canyon and high radiation areas to allow for easy access. These instruments are wired to the local control panel where they provide interlocks with the HCF material transfer system, HCF drum cart transfer system, and waste drum transport and control system. All signals from the local control panel are wired back to PLC I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

7b.3.8 WASTE DRUM TRANSPORT AND CONTROL SYSTEM

The waste storage canyon, located in the basement of the HCF, is directly below the target processing canyon within heavily shielded walls, as described in Subsection 4b.1.2. The waste drums are lowered into the waste storage canyon on carts using the HCF canyon elevator system (A or B) and are staged on the waste drum transport and control system (A or B) for storage and decay. Over time, the waste drum carts are moved along the length of the waste canyon via the waste drum transport and control system (A or B) to the waste canyon cask loading area for shipment off-site.

Interlocks exist between the waste drum transport and control system and the HCF canyon elevator system (A or B). The waste drum transport and control system also positions drums under the waste canyon cask loading area (bay doors A or B) for removal using the waste canyon cask loading system. Signals from the waste drum transport and control system local control panel are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS.

The following DC apply to the design of this system:

- DC 18, Control of Releases of Radioactive Materials to the Environment: The system design shall include means to handle radioactive solid wastes produced during normal operation, anticipated operational occurrences, and accident conditions.
- DC 19, Radioactive Material Control: The design of the waste drum transport and control system controls ensure adequate safety under normal operation, anticipated operational occurrences, and accident conditions. The system design includes capability for appropriate periodic inspection and testing.

7b.3.9 WASTE CANYON CASK LOADING CONTROL SYSTEMS

The waste drums are removed from the waste storage canyon via HCF cask loading bay cranes (A or B) through the waste transfer shaft (A or B) in the cask loading bay (A or B) that allows waste drum loading and shipping operations to be conducted without interference with RF operations and HCF processing operations. The waste drums are loaded into U.S. Department of Transportation Type B shipping containers using remote operations in the cask loading bay and strict personnel access controls to minimize worker exposure.

The shipping cask loading system (A or B) is comprised of cranes that are operated manually by HCF operations personnel using a pendant or a radio control. The cask loading bay cranes move waste drums from the waste canyon transfer shafts (A or B) to the cask loading bay (A or B). The cask loading bay cranes use their own control system and are not part of the HCF control system.

7b.3.10 CRANE SYSTEMS CONTROLS

Four crane systems are used in the HCF:

- HCF target processing high bay bridge crane: Serves the HCF target processing high bay. The crane is used by HCF personnel to lift, move, and position isotope production facility equipment and support systems.

- HCF target processing canyon support crane (gantry crane): Serves the HCF target processing canyon and is located on the top of the exterior walls of the HCF target processing canyon. The crane is used to remove the biological shielding roof panels to support maintenance and scheduled outages.
- HCF target fabrication area bridge crane: Serves the HCF target fabrication area. The crane is used by HCF operations to support on-site manufacturing of low-enriched uranium metal foil targets and to perform routine maintenance and service on high value foundry equipment.
- HCF cask loading bay cranes (A or B): Used to move waste drums from the waste storage canyon transfer system to the cask loading bay.

The cranes are part of the HCF facility; however, the instrumentation and controls for the cranes are stand-alone and will be described in the Operating License Application.

Limitations on crane movements are set by administrative and operational procedures.

7b.3.11 HCF STACK MONITORING CONTROL SYSTEMS

There are two separate stack monitoring systems associated with the HCF. One of the stack monitoring systems uses a CAM in the HCF Zone 1a exhaust stack to monitor for controlled effluents. The second stack monitoring system uses a CAM in the main HCF exhaust stack to monitor the exhaust for controlled effluents for HCF Zones 1b, 1c, 1d, 2, and 3. All process signals for the stack monitoring systems are wired back to I/O modules in the HCF mechanical equipment room for archiving and remote monitoring from the OCDS. Alarms and interlocks are associated with both stack monitoring systems.

7b.3.12 HCF VENTILATION CONTROL SYSTEM

A pressure differential is used to minimize the risk of contamination spread within the HCF and to ensure that all effluent from the HCF exits via a filtered exhaust stack. A detailed description of the HCF ventilation system is in Chapters 6b and 9b. Figure 7b.3-1 presents a block diagram of the HCF ventilation pressure zones.

7b.3.13 HCF HYDRAULIC POWER UNIT

An HPU is used to raise and lower the HCF canyon shield doors. Instrumentation on the HPU monitors the pressure and temperature of the hydraulic fluid as well as ON/OFF control valves. The HPU is controlled from a local control panel located near the HCF canyon shield doors.

7b.3.14 HOT CELL FACILITY PROCESS CONTROL SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

7b.4 HOT CELL FACILITY PROTECTION SYSTEM

The HCF does not include any automatic protective functions and, for this reason, an HCF protection system is not needed.

7b.5 ENGINEERED SAFETY FEATURES ACTUATION SYSTEMS

No engineered safety features (ESFs) have been identified in the HCF that require actuation by the BAS or HCF control system. Monitoring and control of the HCF ventilation system is performed by the BAS to ensure continuous operation. The HCF Zone 1a ventilation system is an ESF as described in Chapter 6b; however, it does not require actuation by the BAS or HCF control system.

7b.6 CONTROL CONSOLE AND DISPLAY INSTRUMENTS

There is no control console or central control room for the HCF. All HCF operations are performed locally at the control panels or OITs at each operating station. An HCF mechanical equipment room houses the HCF PLC and HMI, allowing HCF shift managers, maintenance technicians, and health physicists to monitor any desired subsystem. The HCF control system is connected to the OCDS to allow operators to monitor the HCF systems. All SCB OITs allow remote monitoring of HCF subsystems. Each OIT is programmed to display the appropriate parameters for monitoring and controlling the process at each SCB, including the HCF material transfer system and door interlocks.

7b.7 RADIATION MONITORING SYSTEM

A description of the radiation protection system is in Chapter 11. The RMS includes CAMs for continuous monitoring at the exhaust stacks, process control instruments, and personnel monitoring and dosimetry. The RMS is used to continuously measure and display general area radiation levels and airborne radiation levels in normally occupied areas of the HCF. RMS instruments display the values locally at the instrument and perform local visual and audible annunciation. These values and alarms are also displayed remotely at the OCDS.

There are two exhaust stacks associated with the HCF. The HCF Zone 1a exhaust stack is used for safety-related ventilation and the HCF Zone 1b, 1c, 1d, 2, and 3 exhaust stack is used for nonsafety-related ventilation. Both exhaust stacks use a CAM to measure the airborne radioactivity in the filtered air downstream from filters and fans. The types, location, and alarm setpoints for the RMS instruments will be provided in the Operating License Application.

The following DC apply to the design of this system:

- DC 19, Radioactive Material Control: The radiation monitoring systems are designed to (1) detect conditions that may result in excessive radiation levels and (2) initiate appropriate safety actions. These systems shall be designed with the capability to permit appropriate periodic inspection and testing.
- DC 21, Monitoring Radioactivity Releases: The design of the radiation monitoring system provides for the monitoring of the HCF atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operation, anticipated operational occurrences, and accident conditions via both radiation area monitoring and contamination area monitoring equipment.

7b.7.1 RADIATION MONITORING SYSTEM DESCRIPTION

ARMs and CAMs are incorporated into the overall HCF RMS. The HCF RMS provides the following:

- Overall facility radiation monitoring and alarm coverage.
- Local monitoring display and alarms.
- Radiation monitoring and alarms in the event of a release of radioactive material to the environment.

7b.7.2 RADIATION MONITOR LOCATIONS

ARMs are generally found in areas where personnel may be present and where radiation levels could become significant. The following considerations are used to determine ARM locations:

- Occupancy status of the area, including the length of time personnel are required to spend in the area, the proximity to primary and secondary radioactive sources, and shielding.
- Potential for increase in the background radioactivity level.
- Desirability of surveillance of infrequently visited areas.

CAMs are located in work areas where there is a potential for airborne radioactivity.

ARMs and CAMs are located within the HCF in the following areas:

- HCF mechanical equipment room (basement).
- HCF target fabrication mechanical equipment room (basement).
- HCF target processing mechanical equipment room (basement).
- HCF activation isotope processing area (basement).
- Near canyon shield doors (basement).
- HCF target processing high bay (first floor).
- Target fabrication area high bay (first floor).
- Near canyon shield doors (first floor).
- HCF Zone 1a exhaust stack (first floor).
- HCF exhaust stack (first floor).
- Cask loading bay A (first floor).
- Cask loading bay B (first floor).
- HCF Zone 1a ventilation system.

7b.7.3 RADIATION MONITORING EQUIPMENT DESCRIPTIONS

7b.7.3.1 CAAS Monitoring System

The CAAS is provided as a vendor package with an integrated control system. The CAAS interfaces with the HCF PLC through hard-wired analog and digital signals. The HCF HMI displays the CAAS alarms and values. The HCF control system provides a communication link to provide alarm and status monitoring on the OCDS.

Criticality accidents are prevented by engineered and administrative controls placed on SNM mass and volume limitations throughout the HCF. Section 6b.5 provides a discussion of the Eden Nuclear Criticality Safety Program. A CAAS is implemented for worker safety defense-in-depth. The CAAS provides for continuous monitoring, indication, and recording of neutron or gamma radiation levels in areas where personnel may be present and wherever an accidental criticality event could result from operational processes. Two detectors cover each personnel area needing CAAS coverage. The CAAS provides local and remote annunciation to alarm when radiation levels exceed established setpoints and communicates with the OCDS.

The CAAS meets the criteria of Title 10 of the Code of Federal Regulations 20.1501 and uses the guidance provided by ANSI/ANS 8.3-1997, Criticality Accident Alarm System (R2017) (ANSI/ANS, 2017), International Electrotechnical Commission (IEC) 60860, Radiation Protection Instrumentation – Warning Equipment for Criticality Accidents (IEC, 2014), and Regulatory Guide 3.71, Nuclear Criticality Safety Standards for Nuclear Materials Outside Reactor Cores, Revision 3. The system is comprised of the detection probes, central processing unit, power supply unit (including battery backup), and alarm unit. The CAAS is designed to remain operational during and following credible events, such as seismic shock (equivalent to design

basis earthquake or the equivalent value specified by the Uniform Building Code), fire, explosion, corrosive atmosphere, or other credible conditions.

The following DC applies to the design of this system:

- DC 20, Criticality Control: The design of the criticality accident alarm system provides for the monitoring and indication of radiation levels wherever an accidental criticality event could result in areas where personnel may be present.

The CAAS is considered for four primary areas of the HCF where the potential for a criticality accident exists:

- HCF special nuclear material storage area.
- HCF target processing canyon.
- HCF target fabrication area.
- HCF waste storage canyon.

In the Operating License Application, the criticality safety evaluations performed as part of the Nuclear Criticality Safety Program (Section 6b.5) will be used to determine the exact locations for CAAS implementation.

7b.7.3.2 CAM Equipment Description

CAMs continuously sample and measure the levels of airborne radioactive material in real time and have alarm capabilities. Each monitor has local audible and visual alarms. The CAMs are located where there is a potential for uptake of airborne radioactive particulate matter by personnel. The monitors provide either analog output signals (4 – 20 milliamperes) or digital communications to transmit the signal representing radiation levels. The analog and digital signals from each monitor are compatible with the analog and digital modules in the control system.

The detectors are designed to be operational over a wide range of temperatures. The design of the detectors meets expected normal and abnormal environmental design conditions, as appropriate.

7b.7.3.3 ARM Equipment Description

ARM detector units are housed in an environmentally suitable container mounted in a duct or on a wall or other suitable surface. The sensitivity of each detector is sufficient for the alarm setpoint to be an order of magnitude higher than the detection threshold.

The detectors are designed to be operational over a wide range of temperatures. The design of the detectors meets expected normal and abnormal environmental design conditions, as appropriate.

Sensors are mounted as close as practical to the most probable radiation sources. The sensors are also mounted to minimize inaccuracies due to any directionality of the detector.

Each ARM has local audible and visual alarms. The monitors provide either analog output signals (4 – 20 milliamperes) or digital communications to transmit the signal representing

radiation levels. The analog and digital signals from each monitor are compatible with the analog and digital modules in the control system.

7b.7.3.4 Personnel Contamination Monitoring System

The HCF has PCM systems to detect personnel contamination. This system is integrated with the HCF control system to ensure appropriate alarms and notifications are communicated and archived.

7b.7.3.5 Audible and Visual Alarm Devices

When a ARM or CAM detects radiation above predetermined levels, alarms actuate locally at the ARM or CAM unit. These values and alarms are also displayed remotely at the OCDS.

The alarms consist of:

- An “alert” light that illuminates when the radiation level exceeds preset limits. The setpoint is adjustable.
- A “high” alarm red light that illuminates when radiation levels exceed a predetermined alarm setpoint. The setpoint is adjustable.
- A “failure” alarm that sounds when either the power or the channel's electronics fail.

A simultaneous audible alarm annunciator accompanies the visual alarms both at the selected detector locations and is also displayed remotely at the OCDS. The local alarm horns and warning lights remain on until the radiation level is below the alarm setpoint.

7b.7.4 RADIATION MONITORING SYSTEM TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

7b.8 REFERENCES

ANSI/ANS, 1986. Criteria for the Reactor Safety Systems of Research Reactors, ANSI/ANS-15.15-1978 (R1986), American National Standards Institute, American Nuclear Society, approved 1978, reaffirmed 1986.

ANSI/ANS, 2017. Criticality Accident Alarm System, ANSI/ANS-8.3-1997 (R2017), American National Standards Institute, American Nuclear Society, approved 1997, reaffirmed 2017.

IEC, 2014. Radiation Protection Instrumentation – Warning Equipment for Criticality Accidents, IEC 60860:2014, International Electrotechnical Commission, 2014.

Figure 7b.2-1
HCF I&C Block Diagram

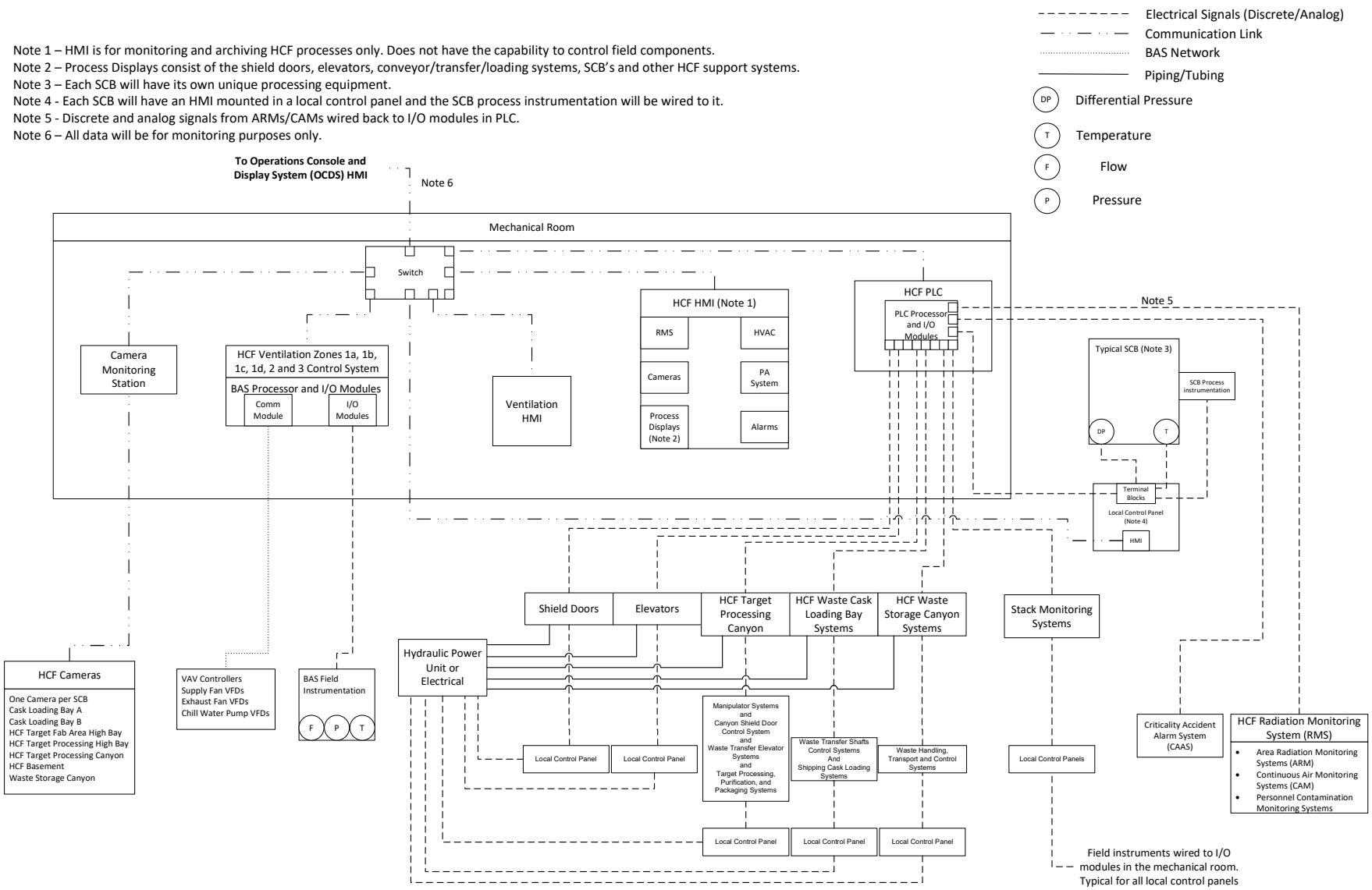


Figure 7b.3-1
HCF Ventilation Pressure Zones

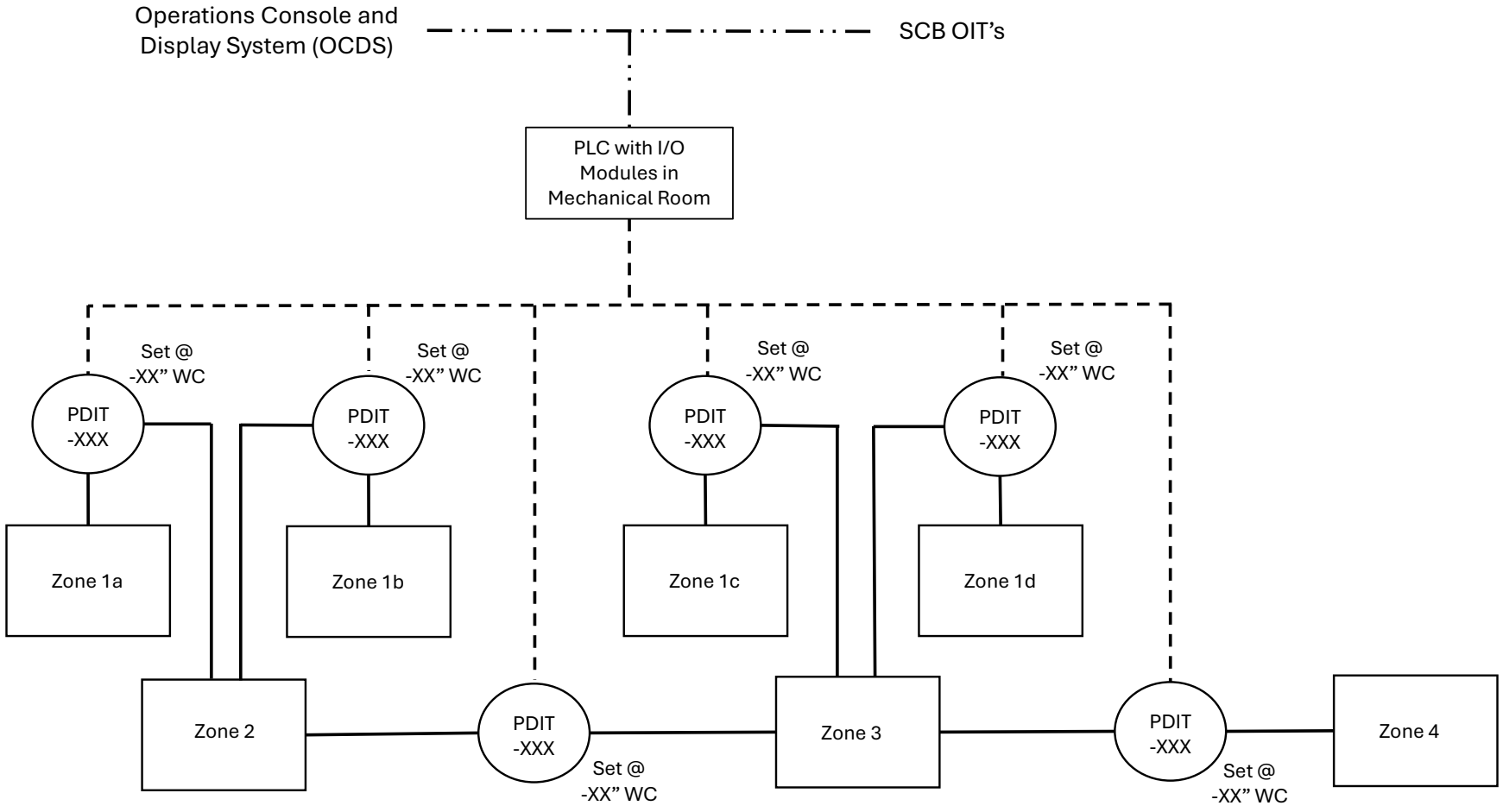
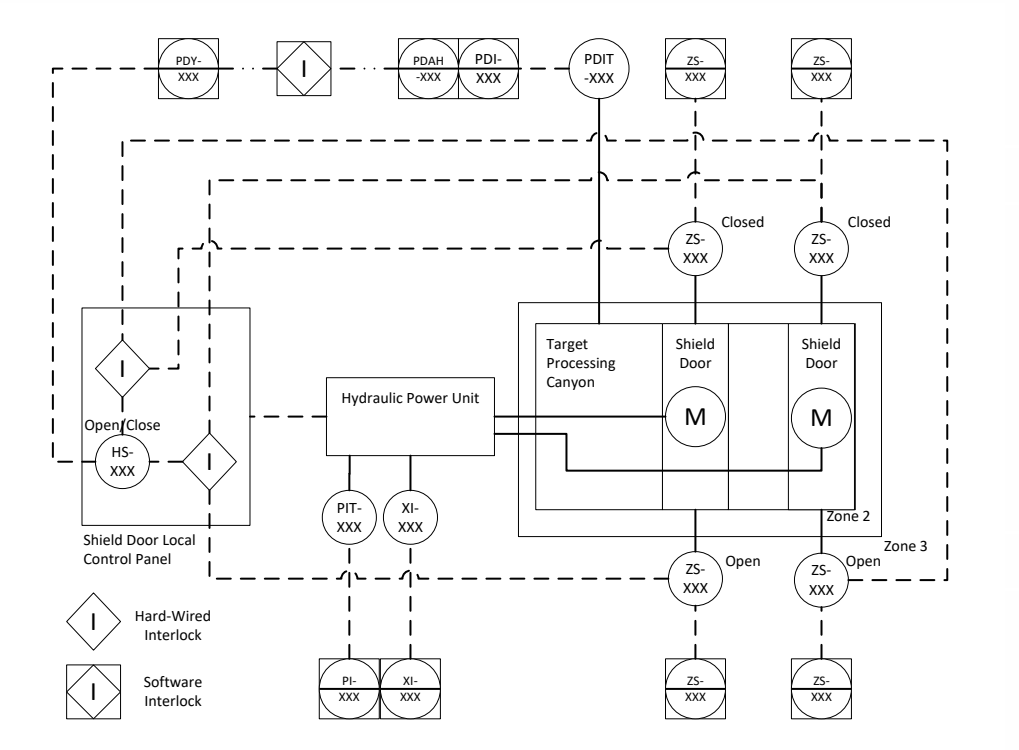


Figure 7b.3-2
HCF Canyon Shield Doors Interlock Logic



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Chapter 8
Electrical Power Systems

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CHAPTER 8

ELECTRICAL POWER SYSTEMS

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8.3-1	Electrical Safety-Related Direct Current Single Line

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
HCF	Hot Cell Facility
IEEE	Institute of Electrical and Electronics Engineers
NFPA	National Fire Protection Association
RF	Reactor Facility
UPSS	uninterruptible power supply system
VAC	volts alternating current

8 Electrical Power Systems

The electrical power system provides electric power to the Eden Isotope Production Complex (EIPC). The EIPC consists of the Eden Medical Isotope Facility (EMIF), which is comprised of the Reactor Facility (RF) and the Hot Cell Facility (HCF), and the other campus buildings which include the Administration Office Complex, the Access Control Center, the Production Office Complex, the Production Warehouse, and the Owner Controlled Area.

The electrical power system is divided into three subsystems: normal, backup, and safety-related. The normal, backup, and safety-related subsystems provide increasing levels of operational redundancy.

The normal electrical power system is designed to provide reasonable assurance that use or malfunction of electrical power systems could not prevent safe shutdown. In addition, the EMIF has a nonsafety backup electrical power system to complete process activities in the HCF upon a loss of off-site power. An uninterruptible power supply system (UPSS) provides safety-related electrical power to the required systems in the EMIF if the backup electrical power system is not available.

8.1 NORMAL ELECTRICAL POWER SYSTEM

8.1.1 DESCRIPTION

Currently, high-capacity electric transmission lines are located north of the EIPC site and run east-west. A connection to the high-capacity transmission lines provides electrical service to the EIPC site. A 10-megavolt-ampere substation and distribution line, installed by the local electric utility, supplements the existing infrastructure. The normal electrical power system is transformed from transmission and distribution voltage levels to a utilization voltage of 480 volts alternating current (VAC), three-phase nominal level.

When the off-site source is available, all facility loads are supplied by the off-site source using a tiered bus configuration as shown in Figure 8.1-1. The tiered bus configuration is used to distinguish between electrical loads that are also backed up by standby diesel generators (backup electrical power system; Section 8.2) and UPSS (safety-related electrical power system; Section 8.3).

The 480 VAC power system is subdivided into four groups of electrical loads of which three groups (A, B, and C) provide service to equipment within the EMIF. Groups A and B typically service RF and HCF loads of either a 2 x 50 percent or 2 x 100 percent configuration. Where there is a third EMIF load (such as a 3 x 50 percent configuration), this third load is typically fed by group C. Group C also typically feeds singular loads (i.e., loads with only a 1 x 100 percent configuration). The fourth group is used to service campus buildings.

Where required, other local uninterruptible power systems are used to provide backup to nonsafety-related loads that are designed to maintain operation during power interruptions.

8.1.2 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The normal electrical power system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following design criterion (DC) applies to the design of this system:

- DC 11, Electrical Power Systems: The nonsafety-related subsystem provides a distribution of power throughout the facility including a level of operational redundancy to minimize the effects of a loss of power on production and to allow for flexibility in performing maintenance. Operational flexibility is provided by bus cross-ties between the three, non-diesel generator backed, buses.

The nonsafety-related normal electrical power subsystem is designed in accordance with the National Fire Protection Association (NFPA) National Electrical Code NFPA 70 (NFPA, 2023).

8.1.3 INSTRUMENTATION AND CONTROLS

System voltages and currents of primary buses and power panels are monitored for deviation from acceptable tolerances. System protection devices are alarmed, allowing for troubleshooting and the restoration of affected portions of the system.

System protection devices are designed to quickly isolate the portion of the system affected by a failure or a fault current. This minimizes the magnitude of available fault current and the potential damage to the system, components, and utilization equipment. Where necessary to maintain critical functions, alternate sources and transfer devices are provided to minimize the duration or the extent of supply and utilization equipment outages.

8.1.4 TESTING AND INSPECTION

The design of the normal electrical power system permits routine testing and inspection without disruption to normal operation. Testing is performed at an appropriate frequency to detect and correct any problems or degradation of the components.

8.2 BACKUP ELECTRICAL POWER SYSTEM

8.2.1 DESCRIPTION

The backup electrical power system provides interruptible power with standby diesel generator backed power on each bus. There are three standby diesel generators, each assigned to an individual bus (A, B, C). Each standby diesel generator is designed to automatically start and re-energize to its associated bus in a time that supports operational activities. Standby diesel generators are capable of carrying the required loads on two standby diesel generator backed buses in the event a standby diesel generator is out of service.

8.2.2 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The backup electrical power system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following DC applies to the design of this system:

- DC 11, Electrical Power Systems: The backup electrical power subsystem provides a level of operational redundancy to minimize the effects of a loss of power on processing irradiated targets and to allow for flexibility in performing maintenance. Redundancy is provided through bus cross-ties between the three standby diesel generator backed buses and sizing of the standby diesel generators.

The nonsafety-related backup electrical power subsystem is designed in accordance with the NFPA National Electrical Code NFPA 70 and NFPA 110, Emergency and Standby Power Systems (NFPA, 2023; NFPA, 2025).

8.2.3 INSTRUMENTATION AND CONTROLS

System voltages and currents of primary buses and power panels are monitored for deviation from acceptable tolerances. System protection devices are alarmed, allowing for troubleshooting and the restoration of affected portions of the system.

System protection devices are designed to quickly isolate the portion of the system affected by a failure or a fault current. This minimizes the magnitude of available fault current and the potential damage to the system, components, and utilization equipment. Where necessary to maintain critical functions, alternate sources and transfer devices are provided to minimize the duration or the extent of supply and utilization equipment outages.

8.2.4 TESTING AND INSPECTION

The design of the backup electrical power system permits routine testing and inspection without disruption to normal operation. Standby diesel generator-backed buses include a test bank connection for a portable load bank. Testing is performed at an appropriate frequency to detect and correct any problems or degradation of the components.

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8.3 SAFETY-RELATED ELECTRICAL POWER SYSTEM

8.3.1 DESCRIPTION

The safety-related electrical power system is powered from the normal electrical power system, in-part, through interconnection with the backup electrical power system (tiered bus configuration).

Safety-related electrical power is provided to HCF Zone 1a ventilation system including fans, dampers, and instrumentation. Primary power to these components is from the normal electrical system buses that are backed by the standby diesel generators. In the case of an event or loss of off-site power with standby diesel generators not available, to inhibit the spread of radionuclides through filtering, the prescribed equipment in HCF Zone 1a and associated controls continue to operate on safety-related UPSS power. Uninterruptible power is supplied via a safety-related battery, battery charger, and inverter combination, or alternately a UPSS, sized to ensure continuity of power for a sufficient time to allow the connected loads to perform their safety function. Figure 8.3-1 depicts the UPSS connections.

8.3.2 DESIGN BASIS AND FUNCTIONAL REQUIREMENTS

The safety-related electrical power system supports the following safety-related functions:

- Supplying safety-related uninterruptible power to the HCF Zone 1a ventilation system including fans, dampers, and instrumentation.
- Isolation of safety-related loads from the normal electrical power system.
- Monitoring and control of the UPSS.

The following DC apply to the design of this system:

- DC 8, Instrumentation and Controls: Instrumentation is provided to monitor variables over their anticipated ranges during normal operation, anticipated operational occurrences, and accident conditions. Controls are provided, where necessary, to maintain these variables within prescribed operating ranges.
- DC 11, Electrical Power Systems: The safety-related electrical power system provides independence, redundancy, and testability to perform their safety functions assuming a single failure.
- DC 22, Inspection, Testing, and Maintenance: Design of the safety-related electrical power system provides for inspection, testing, and maintenance to ensure availability and reliability to perform the required functions.

The safety-related electrical power system is designed in accordance with NFPA 70 (NFPA, 2023) and Institute of Electrical and Electronics Engineers (IEEE) standard IEEE 308-2020, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations (IEEE, 2020).

8.3.3 INSTRUMENTATION AND CONTROLS

System voltages and currents of primary buses and power panels are monitored for deviation from acceptable tolerances. System protection devices allow for troubleshooting and the restoration of affected portions of the system.

System protection devices are designed to quickly isolate the portion of the system affected by a failure or a fault current. This minimizes the magnitude of available fault current and the potential damage to the system, components, and utilization equipment. Where necessary to maintain critical functions, alternate sources and transfer devices are provided to minimize the duration or the extent of supply and utilization equipment outages.

8.3.4 TESTING AND INSPECTION

The design of the safety-related electrical power system permits routine testing and inspection without disruption to normal operation. Testing is performed at an appropriate frequency to detect and correct any problems or degradation of the components.

Relevant safety-related equipment is subject to the testing and inspection requirements of IEEE 338-2022, IEEE Standard for the Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems (IEEE, 2023).

8.3.5 POTENTIAL TECHNICAL SPECIFICATIONS

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

8.4 REFERENCES

IEEE, 2020. IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations, IEEE 308-2020, Institute of Electrical and Electronics Engineers, 2020.

IEEE, 2023. IEEE Standard for the Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems, IEEE 338-2022, Institute of Electrical and Electronics Engineers, 2023.

NFPA, 2023. National Electrical Code, NFPA 70, National Fire Protection Association, 2023.

NFPA, 2025. Standard for Emergency and Standby Power Systems, NFPA 110, National Fire Protection Association, 2025.

Figure 8.1-1
Electrical Power Single Line

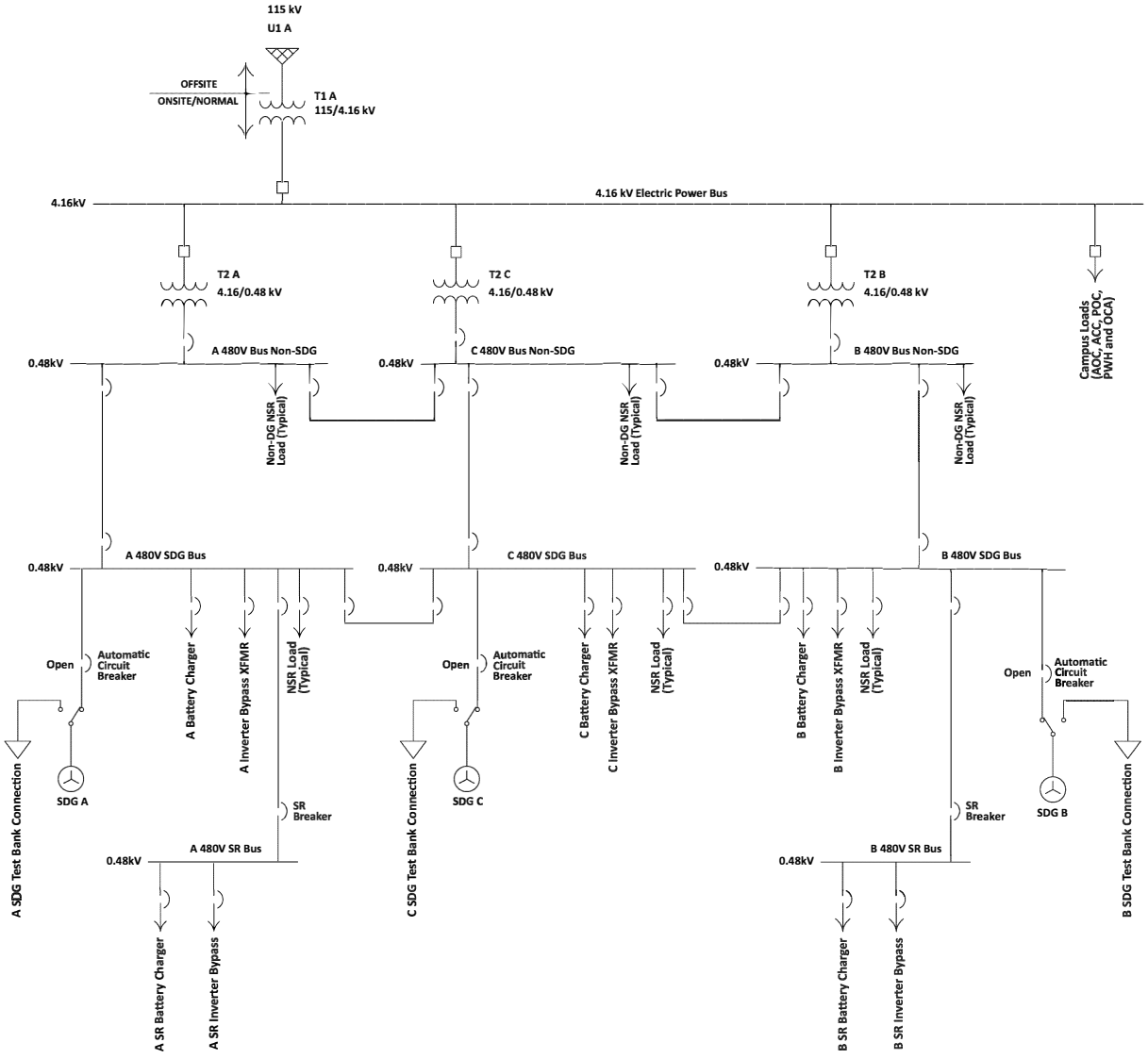
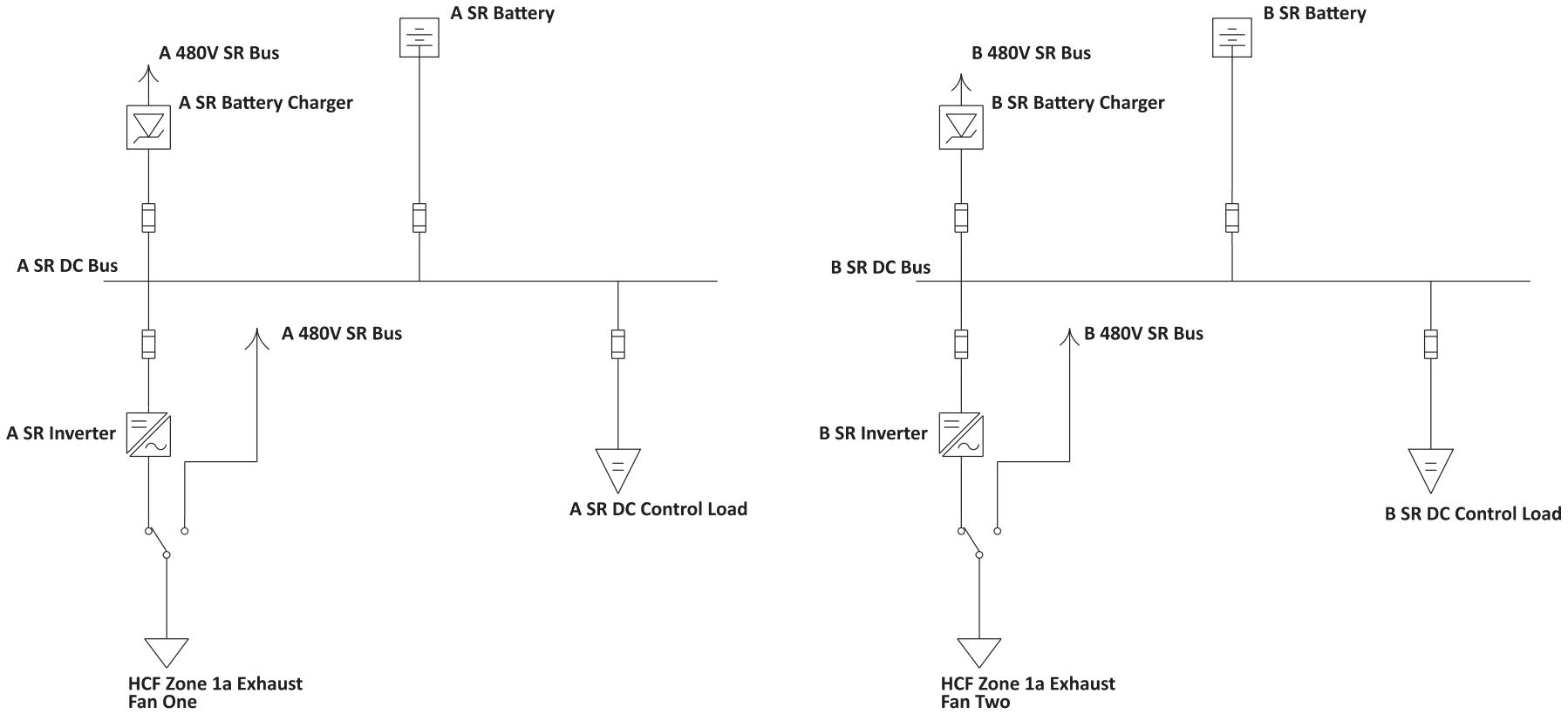


Figure 8.3-1
Electrical Safety-Related Direct Current Single Line



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Chapter 9
Auxiliary Systems

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CHAPTER 9a
REACTOR AUXILIARY SYSTEMS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AHU	air-handling unit
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CMAA	Crane Manufacturers Association of America
DC	design criterion(a)
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
ft.	feet
HCF	Hot Cell Facility
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilation, and air conditioning
k_{eff}	effective neutron multiplication factor
m	meter(s)
NFPA	National Fire Protection Association
NRC	United States Nuclear Regulatory Commission
PSAR	Preliminary Safety Analysis Report
RF	Reactor Facility
SCB	steel confinement box
SNM	special nuclear material
SSC	structure(s), system(s), and component(s)

Acronym/Abbreviation	Definition
U-235	uranium-235

9a. Reactor Auxiliary Systems

This chapter provides an overview description of the auxiliary systems at the Eden Medical Isotope Facility (EMIF), specifically for the Reactor Facility (RF). Auxiliary systems are those systems not previously described elsewhere in this Preliminary Safety Analysis Report (PSAR). The sections that follow provide a description of each auxiliary system, its design basis, and a discussion of the capability to function as designed without compromising facility operation or the capability to safely shut down the facility.

Auxiliary systems addressed in this chapter are:

- Heating, ventilation, and air conditioning (HVAC) systems.
- Handling and storage of reactor fuel.
  - Target handling system.
  - Target transfer system.
- Fire protection system and program.
- Communication system.
- Systems for the possession and use of byproduct, source, and special nuclear material (SNM).
- Cover gas control systems.
- Plant water systems.
- Compressed air system.
- Cranes.

9a.1 HEATING, VENTILATION, AND AIR CONDITIONING SYSTEMS

9a.1.1 REACTOR FACILITY HIGH BAY VENTILATION SYSTEM

9a.1.1.1 System Description

The RF high bay ventilation system (see Figure 9a.1-1) provides the heating, cooling, and ventilation required to condition the air and maintain radiological confinement in the RF high bay area, which includes the RF high bay, reactor cooling system room, and the RF high bay ventilation system room. The system is a once-through ventilation system, which includes the necessary monitoring and filtration to inhibit the spread of radionuclides to the rest of the RF.

The RF high bay ventilation system performs the following nonsafety-related functions:

- Maintains environmental conditions (e.g., air quality, temperature, humidity, pressure).
- Maintains negative pressure within the RF high bay area with respect to surrounding areas.
- Monitors exhaust air vented from the RF high bay area to the RF high bay exhaust stack for controlled effluents.

The system consists of air-handling units (AHUs), (fans, duct work, dampers, and filtration) that draws supply air from the outside atmosphere. Outside air is filtered, heated or cooled in the two (2) x 100 percent capacity AHUs, and directed into the RF high bay. The system is serviced by the chilled water system (i.e., closed-loop cooling using an air-cooled chiller) to meet the cooling demand. The system utilizes electric heat in the AHUs to meet heating demands. Two (2) x 100 percent capacity exhaust fans arranged in parallel (one operating and one in standby) control the flow rate to the RF high bay exhaust stack to maintain a negative pressure in the RF high bay with respect to the rest of the RF and atmosphere. Upstream of the exhaust fans, air from the RF high bay is directed through either a filtered or unfiltered exhaust path. The filtered exhaust path consists of pre-filters, high-efficiency particulate air (HEPA) filters, and charcoal filters.

9a.1.1.2 Design Bases

The RF high bay ventilation system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following design criteria (DC) apply to the design of this system:

- DC 8, Instrumentation and Control: The RF high bay ventilation system includes instrumentation to monitor variables and systems over their anticipated ranges during normal operation, anticipated operational occurrences, and accident conditions as appropriate to ensure adequate safety, including those variables and systems that can affect the confinement and its associated systems. Appropriate controls are provided to maintain these variables and systems within prescribed operating ranges.
- DC 10, Confinement: Systems to control fission products and other substances that may be released into the RF atmosphere shall be provided as necessary to control releases to the environment following postulated accidents. The RF high bay ventilation system is designed to ensure a confinement (negative pressure) is maintained with the RF structure to limit the exchange of effluents between the confinement enclosure and its external environment. The RF high bay ventilation system has filtration, as required, and releases to an elevated stack.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The RF high bay ventilation system is designed to control the release of radioactive materials in gaseous effluents during normal reactor operation, anticipated operational occurrences, and accident conditions.
- DC 21, Monitoring Radioactivity Releases: The RF high bay ventilation system is designed to provide for monitoring the RF high bay effluent discharge paths for radioactivity that may be released during normal operations, anticipated operational occurrences, and accident conditions.

9a.1.1.3 System Evaluation

The RF high bay ventilation system is designed to local building codes and the following relevant codes and standards:

- American National Standards Institute (ANSI)/American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) 62.1-2022, Ventilation and Acceptable Indoor Air Quality (ANSI/ASHRAE, 2022).
- ASHRAE 90.1-2022, Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition (ASHRAE, 2022).
- American Society of Mechanical Engineers (ASME) AG-1, Code on Nuclear Air and Gas Treatment (ASME, 2023).

The RF high bay ventilation system is not credited for the filtration of radionuclides for minimizing dose consequences during postulated events. During normal operation the system is operated in the unfiltered mode; however, the system has the capability to operate in a filtered mode for defense-in-depth purposes. This feature provides for the control of radioactive gaseous effluents. This satisfies the requirements of DC 10, and DC 18. Appropriate instrumentation and controls are provided to satisfy the requirements of DC 8.

The discharge pathway for the RF high bay ventilation system is monitored for radioactivity during normal plant operations. This satisfies the requirements of DC 21.

9a.1.1.4 Technical Specifications, Testing, and Inspection

The design of the RF high bay ventilation system permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9a.1.2 REACTOR FACILITY GENERAL AREA HVAC SYSTEM

9a.1.2.1 System Description

The RF general area HVAC system (see Figure 9a.1-2) provides conditioned air for workers and equipment in the other areas outside of the RF high bay to meet heating and cooling demands. Specific areas include the reactor control room, personnel monitoring area, radiological control technician room, RF HVAC system room, RF garage, and RF maintenance room.

The RF general area HVAC system performs the following nonsafety-related functions:

- Maintains environmental conditions (e.g., air quality, temperature, humidity, pressure).

The system is a recycled air system that consists of fans, duct work, dampers, and AHUs and uses a mix of outside air and return air to supply the non-high bay areas, while exhaust/relief air prevents over pressurization. The mixed air is filtered in the two (2) x 100 percent capacity AHUs and directed to the RF non-high bay areas.

9a.1.2.2 Design Bases

The RF general area HVAC system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following DC apply to the design of this system:

- DC 12, Control Room: A control room shall be provided from which actions can be taken to operate the facility safely under normal conditions and anticipated operational occurrences. Measures are provided to permit access and occupancy of the control room during normal operations and anticipated operational occurrences and egress under accident conditions.

9a.1.2.3 System Evaluation

The RF general area HVAC system is designed to local building codes and the following relevant codes and standards:

- ASHRAE 62.1-2022 (ANSI/ASHRAE, 2022).
- ASHRAE 90.1-2022 (ASHRAE, 2022).

9a.1.2.4 Technical Specifications, Testing, and Inspection

The design of the RF general area HVAC system permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9a.2 HANDLING AND STORAGE OF REACTOR FUEL

Two systems are used to move targets (fuel) to and from the RF and Hot Cell Facility (HCF); the target handling system, located in the RF, and the target transfer system, an RF and HCF shared system located in the transfer canal. The target handling system is used to remove one or more irradiated targets from the reactor core, place them into the target transfer basket, and replace them in the reactor core with fresh targets. The target transfer system is used to move the irradiated targets through the transfer canal from the reactor pool to the first steel confinement box (SCB-1, target receipt box) in the HCF target processing canyon. The target transfer system is also used to move fresh targets through the transfer canal from the HCF to the RF.

9a.2.1 TARGET HANDLING SYSTEM

9a.2.1.1 System Description

The target handling system is a semi-automatic system that is used to remove one or more irradiated targets from the reactor core, move them to the target transfer system, and replace them in the reactor core with fresh targets. The target handling system is operated by United States Nuclear Regulatory Commission (NRC)-licensed RF reactor operators under the supervision of an NRC-licensed RF senior reactor operator. Target transfer into and out of the reactor core grid is performed with the reactor subcritical in the target transfer mode (control and safety rods in the full down position with nuclear instrumentation operational).

Efficient use of time is important when moving targets into and out of the reactor. An operational goal is to remove irradiated targets and replace with fresh targets within a two-hour window. Should this operation extend past this window, restart of the reactor may be significantly delayed due to xenon-135 reactivity poisoning effects, as described in Subsection 4a.5.3.4.

Key elements of the target handling system are shown in Figure 9a.2-1. The target handling system is designed to laterally traverse the pool on a rail and cable drive system integrated into the reactor bridge. The drive system allows the target handling system to move from one side of the reactor pool to the other using a programmable control system with interlock features. The target handling system incorporates a telescoping feature that allows axial motion from a full up position to a full down position. When in the full up position, the lower portion of the target handling system clears the reactor chimney, approximately 4.3 meters (m) (14.0 feet [ft.]) from the pool surface. The mechanical design limits the full up position such that the irradiated targets remain in the pool at a level that limits the radiation exposure to the worker. When in the full down position over the reactor core, the base of the target handling system aligns with positioning features on the reactor core grid. This ensures that the telescoping structure is located at a precise position when placing or removing the targets. When not in use, the target handling system is parked at the side of the pool in the full up position.

The basic operation of the target handling system is as follows:

1. Initial condition – target handling system is parked at the side of the reactor pool in a de-energized state with the reactor operating.
2. Target transfer mode – the reactor is placed subcritical (control and safety rods in the full down position with nuclear instrumentation operational).

3. System is energized for pre-operational checks in its parked configuration at the side of the pool.
4. Irradiated target selection for removal from the reactor core is programmed into the unit.
5. Verification of replacement fresh target supply in the target transfer system fresh target transfer basket is performed and documented. (Note: The fresh target transfer basket is preloaded in the target receipt box by HCF operators and positioned at the pool by RF operators.)
6. System is positioned laterally and locked directly over the reactor core.
7. System telescoping feature is extended to the full down position over the reactor core grid.
8. Selected targets are captured mechanically with the grapple system using the top end fitting of each target.
9. Verification of capture of the intended selected targets is performed and documented.
10. Grapple system is raised, drawing selected irradiated targets into the guide tubes.
11. System telescoping feature is raised to the full up position.
12. System is laterally positioned and locked over the target transfer system irradiated target transfer basket located in the transfer canal.
13. System telescoping feature is lowered to the full down position over the irradiated target transfer basket.
14. Grapple system is lowered, allowing targets to be placed into the irradiated target carrier located in the irradiated target transfer basket.
15. Targets are mechanically released from the grapple system.
16. Verification of release of the intended selected targets is performed and documented.
17. System telescoping feature is raised to the full up position.
18. System is positioned laterally and locked over the preloaded target transfer system fresh target transfer basket located in the transfer canal.
19. System telescoping feature is lowered to the full down position over the fresh target transfer basket.
20. Selected fresh targets are captured mechanically with the grapple system using the top end fitting of each target.
21. Verification of capture of the intended selected targets is performed and documented.
22. Grapple system is raised, drawing selected fresh targets into the guide tubes.
23. System telescoping feature is raised to the full up position.
24. Target handling system is positioned laterally and locked directly over the reactor core.
25. System telescoping feature is lowered to the full down position over the reactor core grid.
26. Grapple system is lowered, allowing fresh targets to be placed into the reactor core.
27. Fresh targets are mechanically released from the grapple system.

28. Verification of release and proper seating of the intended selected fresh targets is performed by mechanical and optical means and documented.
29. System telescoping feature is raised to the full up position.
30. Target handling system is moved laterally to the parked position at the side of the reactor pool and de-energized.
31. The correct target transfer and seating placement within selected reactor core positions is re-verified by optical means and documented.
32. Target transfer mode (control and safety rods in the full down position with nuclear instrumentation operational) is complete and the reactor is returned to operating mode.

The system's telescoping feature, as shown in Figure 9a.2-2, is raised and lowered using four stainless-steel lift cables, one at each corner of the suspended system. The total calculated mass of the handling system with a maximum target load is approximately 100 kilograms (220 pounds).

Within the target handling system, shown in Figure 9a.2-3, guide tubes are integrated into the lower portion of the structure to locate the targets in a vertical and controlled position during movement. The guide tubes contain mechanically driven grapple units, one for each target location in the grid.

The target handling system latches onto the pre-selected target end fittings, as shown in Figure 9a.2-4, using the mechanical grapple latch system. As the lift cables are taken up, those targets for which the grapple has been enabled are moved up into the guide tubes of the handling system. Verification of target capture is performed by mechanical and visual means.

The irradiated targets, secured by the grapple system within the lower portion of the target handling system, are lifted vertically to a controlled full up position, allowing them to clear the reactor chimney. The target handling system is then translated horizontally to a controlled location directly above the irradiated target transfer basket, a component of the target transfer system as shown in Figure 9a.2-5. The target transfer system is discussed in Subsection 9a.2.2. The irradiated targets are transferred to the irradiated target transfer carrier, a component of the irradiated target transfer basket, by lowering the grapple system. Refer to Figure 9a.2-6.

The grapple system is mechanically de-energized to release the targets. The targets can only be released when the target transfer system is in the full down position at the reactor core or transfer basket to prevent unintended release from the mechanism.

The target handling system is then moved over the fresh target transfer basket as shown in Figure 9a.2-7. The grapple system is attached to the fresh targets, and the fresh targets are moved to the reactor core, where they are placed for irradiation.

The target handling system can be removed from the reactor pool for maintenance using the RF high bay bridge crane. Movement of the system into or out of the pool is performed with the reactor subcritical.

Final design and operational details will be provided in the Operating License Application.

9a.2.1.2 Design Bases

The following DC apply to the design of this system:

- DC 19, Radioactive Material Control: Target storage and handling is designed to ensure adequate safety under normal operation, anticipated operational occurrences, and accident conditions. Irradiated targets are transferred and stored underwater in the reactor pool or transfer canal. Target storage and transfers are performed in the pool or transfer canal with sufficient water shielding. The systems are designed to permit inspection and testing. The pool water also provides scrubbing of fission products that escape from a target if damaged during movement.
- DC 20, Criticality Control: Criticality in target storage and handling is prevented by use of geometrically safe configurations. All handling of SNM at the RF is performed under the Nuclear Criticality Safety Program. Fresh and irradiated targets are stored in the reactor pool or transfer canal in criticality-safe conditions. In the pool or in the transfer baskets, 60 targets cannot be made into a critical configuration in water. In fresh and irradiated target transfer baskets, separation control between the configurations is sufficient to ensure a criticality-safe configuration.

9a.2.1.3 System Evaluation

The target handling system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following topics are considered in the system evaluation:

- Criticality.
- Loss of normal electrical power.
- Dropping targets.
- Uncontrolled movement.
- Irradiated target height in the pool.

Criticality

By design, the target handling system is criticality safe. As described in Subsection 9a.2.1.1, the target handling system is only operated with the reactor subcritical in the target transfer mode (control and safety rods in the full down position with nuclear instrumentation operational). Sixty targets, the maximum number of target locations in the reactor core, cannot achieve a critical condition in water without the use of a beryllium reflector. As the targets are removed from the reactor core or from the fresh target transfer basket, they are loaded into stainless steel guide tubes. The guide tubes further reduce the k_{eff} (the effective neutron multiplication factor), providing an additional margin of safety. Dropping targets onto the reactor core cannot create a critical condition.

Loss of Normal Electrical Power

In the event of loss of normal electrical power, the system is de-energized and remains de-energized until power is restored. Mechanical interlocks are incorporated into the cable lift system to prevent downward movement of the telescoping structure of the system during a loss of normal electrical power. Mechanical interlocks are also incorporated into the system's traverse drive motors. When de-energized, all the system's motors stop and lock in place. A manual restart of the system by the operator is required after a loss of normal electrical power.

The grapple system incorporates a mechanical (non-electrical) latch system that (by design) is not affected by a loss of normal electrical power.

Dropping Targets

The design of the grapple system incorporates a mechanical latching system to ensure a positive latch is maintained at all times during movement of the system. The system is designed such that unlatching of the grapple from the targets can only occur when the system is in a full down position at the reactor core or target basket. However, dropping irradiated or fresh targets is considered credible. The robust design of the targets minimizes the probability that a cladding failure would occur from being dropped. This accident for irradiated targets is analyzed in Subsection 13a.2.3.5. Dropped irradiated or fresh targets cannot create a critical condition.

Uncontrolled Movement

The design of the system utilizes mechanical interlock features that prohibit unintended motion (lateral and axial) when removing or placing targets in the reactor core or transfer basket. The interlocks are designed to prevent system movement that could cause damage to the targets or the components in the reactor pool. The system is designed such that lateral movement does not have any impact on the safety-related structures, systems, and components (SSCs) (reactor control and safety rods).

Irradiated Target Height in the Pool

A key safety feature of the system is that targets cannot be raised in the pool to an elevation that could jeopardize worker safety by causing too high of a radiation exposure rate. If reactor pool water level is within acceptable limits, the upper structural mechanical limits of the system are designed to have sufficient pool water shielding at all times.

9a.2.1.4 Technical Specifications, Testing, and Inspection

The target handling system is designed for appropriate testing and inspection. Details will be provided in the Operating License Application.

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

9a.2.2 TARGET TRANSFER SYSTEM

The target transfer system (a shared system between the RF and HCF) is a semi-automatic system located in the transfer canal that is used to move fresh and irradiated targets underwater

between the RF and HCF. Irradiated targets from the RF are transferred through the transfer canal to SCB-1 in the HCF target processing canyon. This SCB is referred to as the target receipt box. Fresh targets are transferred from the target receipt box through the transfer canal to the reactor pool.

9a.2.2.1 System Description

Key elements of the target transfer system are shown in Figure 9a.2-8. Translational movement of the irradiated and fresh target transfer baskets between the facilities is performed by RF personnel. Vertical movement of the irradiated and fresh target transfer baskets using the transfer canal elevator (located underneath the target receipt box) is performed by HCF personnel.

The system is made up of two collocated 60-target transfer baskets, one for irradiated targets and one for fresh targets, as shown in Figure 9a.2-9. Irradiated and fresh targets are placed into their respective carriers within the baskets. Conduct of operations is strictly defined and followed for these activities. The carriers are designed to replicate the reactor core pitch, ensuring accurate target interface during placement and retrieval using the target handling system (see Subsection 9a.2.1). The irradiated and fresh target transfer baskets with fully loaded carriers are designed to be criticality safe. The carriers use stainless steel guide tubes that further reduce the k_{eff}, providing an additional margin of safety. The maximum number of targets that can be loaded into each carrier at one time is 60. Under normal operation, it is anticipated that up to 24 targets are transferred at one time.

The transfer baskets can move independently or together in the transfer canal on a rail system using a magnetically coupled cable drive system. After being loaded with irradiated targets, the irradiated target transfer basket is moved to the HCF under the target receipt box. After removal from the reactor core, irradiated targets remain in the transfer canal to decay for a minimum of 4 hours. Target transfers have no effect on reactor operations and are performed while the reactor is at full power.

After decay, the irradiated target transfer basket is lifted vertically into the target receipt box by the transfer canal elevator system as shown in Figure 9a.2-10. The elevator system incorporates a rail cable motor drive system with electromechanical interlocks that is operated by HCF personnel at a station located next to the HCF target receipt box. The portion of the elevator system located in the lower region of the transfer canal is shown in Figure 9a.2-11.

Once the elevator is in the full up position in the target receipt box, the irradiated targets are removed from the carrier by HCF operators and staged for production processing. The empty irradiated target transfer basket is returned through the transfer canal to the RF and staged for the next irradiated target retrieval cycle.

When the fresh target transfer basket is emptied, it is moved through the transfer canal to the target receipt box in a fashion similar to that described for the irradiated target transfer basket. Upon loading with fresh targets by HCF personnel, the fresh target transfer basket is returned to the RF through the transfer canal and staged for the next fresh target reactor core loading cycle.

While the target transfer system is a shared facility system, the design allows for the independent removal of components from the transfer canal for maintenance using the RF high bay bridge crane or the HCF target processing high bay bridge crane as needed to access the system components.

Final design and operational details will be provided in the Operating License Application.

9a.2.2.2 Design Bases

The following DC apply to the design of this system:

- DC 19, Radioactive Material Control: Target storage and handling is designed to ensure adequate safety under normal and postulated accident conditions. Transfer and storage of irradiated targets underwater in the reactor pool or transfer canal occur with sufficient water shielding. Irradiated target transfers between the upper region of the transfer canal and the target receipt box are performed in air at a location where sufficient shielding is provided by the HCF target processing canyon. The systems are designed to permit inspection and testing. The pool water provides scrubbing of fission products that escape from a target if damaged during movement.
- DC 20, Criticality Control: Criticality in target storage and handling is prevented by use of geometrically safe configurations. Handling of SNM at the RF and HCF is performed under the Nuclear Criticality Safety Program. Fresh and irradiated targets are stored in the reactor pool, transfer canal, and target receipt box in criticality-safe conditions. In the pool or in the transfer baskets, 60 targets cannot be made into a critical configuration in water. In fresh and irradiated target transfer baskets, separation control between the configurations is sufficient to ensure a criticality-safe configuration.

9a.2.2.3 System Evaluation

The target transfer system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The following topics are considered in the system evaluation:

- Criticality.
- Loss of normal electrical power.
- Mishandled targets during loading or unloading of transfer baskets.
- Uncontrolled movement.
- Irradiated target height in the transfer canal.

Criticality

By design, the target transfer system is criticality safe. 60 targets, the maximum number of target locations in the reactor core, cannot achieve a critical condition in water without the use of a beryllium reflector. The maximum number of irradiated or fresh targets that can be placed in their respective transfer baskets is 60. By design, the transfer baskets are constructed to prevent a critical condition. Irradiated and fresh targets are placed inside stainless steels tubes within the target basket carrier that further reduce the k_{eff}, providing an additional margin of safety. Dropping targets onto the top of either transfer basket cannot create a critical condition.

Loss of Normal Electrical Power

In the event of loss of normal electrical power, the system is de-energized and remains de-energized at its current location until power is restored. Translation and axial movement of irradiated and fresh transfer baskets is provided by independent rail cable drive systems that utilize fully captured trolly wheel components. The trolly system design for both translational and axial motion ensures the target baskets remain on their respective rail systems at all times. Electromechanical interlocks are incorporated in the rail cable drive systems to prevent movement during a loss of normal electrical power. When de-energized, all the system's motors stop and lock in place. A manual restart of the system by the operator is required after a loss of normal electrical power.

Mishandled Targets During Loading or Unloading of Transfer Baskets

The loading and unloading of irradiated and fresh target transfer baskets only occurs in two locations, in the reactor pool and within the HCF target receipt box. At the reactor pool, the design of the target handling system's grapple feature includes a mechanical latching system to ensure a positive latch on the target is maintained at all times during loading and unloading. Unlatching of the grapple from the targets can only occur when the system is in a full down position located precisely above a target basket. The target transfer system incorporates mechanical features to ensure the transfer baskets are properly located during basket loading and unloading.

Dropping irradiated or fresh targets is considered credible. The robust design of the targets minimizes the probability that a cladding failure would occur from being dropped. However, this accident for irradiated targets is analyzed in Subsection 13a.2.3.5. Dropped irradiated or fresh targets cannot create a critical condition.

Uncontrolled Movement

The design of the system utilizes electromechanical interlock features that prohibit unintended motion (lateral and axial) when removing or placing targets in the transfer baskets, during transfers between the RF and HCF, or entry to and exit from the target receipt box. Translation and axial movement of irradiated and fresh transfer baskets is provided by independent rail cable drive systems that utilize fully capture trolly wheel components. The trolly system design for both translational and axial motion ensures the target baskets remain on their respective rail systems at all times. The electromechanical interlocks are designed to prevent system movement that could cause damage to the targets or the components in the reactor pool, transfer canal, or the target receipt box.

Irradiated Target Height in the Transfer Canal

A key safety feature of the system is that targets cannot be raised in the transfer canal to an elevation in the RF or HCF that could jeopardize worker safety by causing too high of a radiation exposure rate. The target transfer system is operated through the transfer canal under at least 14 ft. (4.3 m) of water along the entire length between the reactor pool and the location underneath the target receipt box, providing sufficient water shielding. Moving target baskets between the transfer canal and target receipt box is performed within the HCF target processing canyon. The HCF target processing canyon provides biological worker radiation protection.

9a.2.2.4 Technical Specifications, Testing, and Inspection

The target transfer system is designed for appropriate testing and inspection. Details will be provided in the Operating License Application.

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

9a.3 FIRE PROTECTION SYSTEM AND PROGRAM

9a.3.1 FIRE PROTECTION PROGRAM

The primary objectives of the Fire Protection Program are:

- To prevent fires from starting, accomplished in part by limiting the types and quantities of combustible materials present.
- To detect, control, and extinguish promptly those fires that do occur.
- To provide protection for SSCs so that a fire that is not promptly extinguished by the fire suppression activities does not prevent the safe shutdown of the facility or result in an uncontrolled release of radioactive material.

The Fire Protection Program addresses those SSCs that could affect safety or the protection of licensed materials. In addition, the fire protection system is designed such that failure or inadvertent operation does not adversely impact the ability of the SSCs to perform their safety functions.

A more detailed description of the Fire Protection Program and a fire hazards analysis will be provided in the Operating License Application.

9a.3.2 FIRE PROTECTION SYSTEM

9a.3.2.1 System Description

The fire protection system is designed to detect, control, and extinguish fires so that a continuing fire does not prevent safe shutdown or result in an uncontrolled release of radioactive material that exceeds acceptance criteria. The fire protection system does not perform safety-related functions.

The fire protection system includes fire detection and alarm systems as well as automatic and manual fire suppression systems. Manual fire suppression systems and equipment include hydrants, standpipes, hose stations, and portable fire extinguishers. Equipment to support these manual systems and plans includes manual fire alarm pull boxes and dry chemical portable fire extinguishers throughout the facility, as well as the emergency communications system. Design features such as fire barriers and fire area penetration protection are included to provide for life safety provisions and to minimize the spread of fire. Fire protection system elements and design features are identified and installed in defined fire areas based on the results of the fire hazards analysis. Where required by the fire hazards analysis, automatic fire protection systems are installed. Manual pull stations are installed to allow personnel to activate the fire protection system.

9a.3.2.2 Design Bases

The following DC apply to the design of this system:

- DC 3, Fire Protection: Non-combustible and fire-resistant materials are used whenever practical, particularly in locations with SSCs that are safety-related or required for safe shutdown. Fire detection and fighting systems of appropriate capacity and capability are provided and designed to minimize the adverse effects of fires on these SSCs, and

firefighting systems are designed to ensure that their rupture or inadvertent operation does not impair the safety capability of these SSCs.

9a.3.2.3 System Evaluation

The fire protection system does not perform safety-related functions and is not credited to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

The fire protection system conforms to local building and fire codes and the following relevant codes and standards:

- ANSI/American Nuclear Society (ANS) 15.17-1981, Fire Protection Program Criteria for Research Reactors (R2000) (ANSI/ANS, 2000).
- National Fire Protection Association (NFPA) 801, Standard for Fire Protection for Facilities Handling Radioactive Materials (NFPA, 2025a).
- NFPA 72, National Fire Alarm and Signaling Code (NFPA, 2025b).
- NFPA 101, Life Safety Code (NFPA, 2024).

SSCs and equipment required for safe shutdown of the reactor and prevention of an uncontrolled release of radioactive material are located within the EMIF. The floors, walls, and ceilings of the EMIF are constructed of materials rated as required to prevent propagation of fire. Fire detection and suppression capability provided by the fire protection system minimizes the potential for adverse effects of fires on safety-related SSCs. Fire water piping is routed such that a rupture or inadvertent operation of the fire protection system does not significantly impair safety-related or safe shutdown functions. These design features, in conjunction with the Fire Protection Program, satisfy DC 3.

The fire protection system is not safety-related, but portions of this system may experience differential displacements as a result of seismic events. The fire protection system is designed so that postulated failures of SSCs in the system from differential displacements do not preclude safety-related SSCs from performing a safety function.

Firefighting water expended within the EMIF during a fire event is collected, sampled, and removed, as necessary. The method of collection will be identified in the Operating License Application.

9a.3.2.4 Technical Specifications, Testing, and Inspection

Functional tests of the fire protection system are performed prior to startup and periodic functional tests and inspections of the system are performed during facility operation.

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

9a.4 COMMUNICATION SYSTEM

9a.4.1 DESCRIPTION

The communication system provides communications during normal and emergency conditions throughout areas of the EMIF, as well as locations remote to the EMIF. The system is also capable of announcing an emergency condition across the Eden Isotope Production Complex (EIPC). The diverse technologies are described in the subsections below. A detailed description of the communication system will be provided in the Operating License Application.

9a.4.2 NORMAL AND EMERGENCY COMMUNICATION

The communication system provides normal and emergency communication capabilities and is comprised of the following subsystems:

- Plant radio.
- Public address and general alarm.
- Communication capability in the event of a loss of normal power.
- Distributed antenna.
- Security communications.

The facility uses a communication system that provides paging, alarming, and party-line-type voice communications and communications broadcasting. Stations for this system are located throughout the facility. The stations are modular in design for ease of replacement. In an emergency, this system is used to alert personnel.

The communication system uses diverse voice over internet protocol and commercial land and cellular phone lines in combination, in the reactor control room and several other locations within and outside the EMIF.

In an emergency, the public address system is used to alert personnel. The details for the communication system to provide provisions for summoning emergency assistance from designated personnel are discussed in the physical security and emergency plans as appropriate.

9a.4.3 OFF-SITE COMMUNICATION

Commercial land and cellular telephone lines are provided in normally occupied areas of the EIPC. These phone lines allow personnel to contact any outside telephone number in the case of an emergency. In the event of a postulated event or security event, off-site communication, including with the NRC, emergency responders, or local law enforcement, is addressed in the physical security plan and emergency plan discussed in Chapter 12.

9a.4.4 TECHNICAL SPECIFICATIONS, TESTING, AND INSPECTION

The diverse implementation of the communications system permits routine testing and inspection without disruption to normal communications. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the communications system.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9a.5 POSSESSION AND USE OF BYPRODUCT, SOURCE, AND SPECIAL NUCLEAR MATERIAL

This section applies to the possession and use of byproduct, source, and SNM within the EMIF. The receipt, possession, and use of byproduct, source, and SNM is in accordance with regulations in Title 10 of the Code of Federal Regulations (10 CFR) Part 30, 10 CFR Part 40, and 10 CFR Part 70.

The 10 CFR Part 50 Operating License and the incorporated 10 CFR Part 30, 40 and 70 licenses apply to the possession and operation of the reactor, possession and use of byproduct and SNM materials produced by the operation of the reactor, and, to the extent authorized, the receipt, possession and use of other byproduct, source, or SNM needed for operation of the EMIF. Byproduct and SNM are separated within the HCF, which is licensed as a production facility.

The exact quantities, isotopes and forms will be included in the Operating License Application.

9a.5.1 SPECIAL NUCLEAR MATERIAL

The EMIF receives, possesses, and uses SNM in the following forms:

- Uranium metal or oxide enriched to less than 20 percent uranium-235 (U-235) for use as reactor fuel (targets).
- Uranium metal or oxide enriched to any value U-235 in the form of fission chambers.
- Such SNM that may be produced as a result of operating the facility.

9a.5.2 SOURCE MATERIAL

The EMIF receives, possesses, and uses source material in the following forms:

- Sealed depleted uranium transfer shields for the movement of radioactive materials within the HCF.

9a.5.3 BYPRODUCT MATERIAL

The EMIF receives, possesses, and uses byproduct material in the following forms:

- Sealed americium-beryllium neutron sources or other neutrons sources for reactor startup.
- Sealed check and calibration sources for radiation protection instrument calibration.
- Sealed mixed gamma-ray sources for calibration of germanium detectors in the HCF metrology laboratory.
- Sealed alpha and beta sources for calibration of detectors in the HCF metrology laboratory.
- Such byproduct material that is produced by operation of the facility.

9a.6 COVER GAS CONTROL IN CLOSED PRIMARY COOLANT LOOP

The reactor tank does not have a cover-gas controlled atmosphere. The reactor pool is open to the high bay environment.

9a.7 OTHER AUXILIARY SYSTEMS

This section provides a summary description of other RF auxiliary systems not described elsewhere in this PSAR. These include plant water systems, the compressed air system, and the RF high bay bridge crane.

9a.7.1 PLANT WATER SYSTEMS

Plant water systems described in this subsection provide general facility support such as maintenance, makeup, cooling, and site sanitary services. The water systems described below are nonsafety-related.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification associated with the water systems discussed in this subsection.

9a.7.1.1 Potable Water System

The potable water system serves as the main supply of water for the facility and is supplied by municipal sources. The system receives and stores water and distributes it to site services. The potable water system is comprised of piping from the municipal supply, storage tanks, filters, pumps, and distribution piping. The system is designed in accordance with local building codes.

9a.7.1.2 Industrial Wastewater System

The industrial wastewater system collects from potentially radioactive systems and discharges to the evaporation pond after monitoring in the liquid effluent control system as described in Chapter 11.

9a.7.1.3 Sanitary Wastewater System

The sanitary wastewater system collects from non-radioactive systems and discharges directly to the Eunice Municipal Wastewater Facility. The system comprises supply piping, pumps, and distribution and discharge piping. The system is designed in accordance with local building codes.

9a.7.1.4 Chilled Water System

The chilled water system provides cooling water to the HVAC systems in the EMIF. The system is comprised of electric air-cooled chillers, supply/return piping, heat exchangers, storage tanks, and distribution piping. The system is designed in accordance with local building codes.

9a.7.2 COMPRESSED AIR SYSTEM

The compressed air system provides and distributes clean, filtered, compressed air for maintenance and operational needs. The system includes distribution piping, valves, compressors, coolers, moisture separators, filters, and receivers. The system does not provide compressed air that is credited to perform safety-related functions, nor does it directly interface with systems that contain or have the potential to contain radioactive materials.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9a.7.3 HIGH BAY BRIDGE CRANE

9a.7.3.1 System Description

The RF high bay bridge crane is an overhead crane that serves the RF high bay. The crane coverage area includes the RF high bay with access above the pool, reactor, transfer canal, and support systems in the reactor cooling system room and the RF high bay ventilation system room.

The crane is designed to have sufficient rated load and hook height to support lifting, movement, and positioning of equipment and reactor support systems during routine operations and maintenance activities. During reactor outage periods, the crane is used to perform service, maintenance, repair, and test and checkout of reactor, reactor subcomponents, and hardware.

The crane is operated manually by reactor operations personnel using a pendant or a radio control. The crane operation includes provisions to control hoist and bridge/trolley speeds with soft start and stop functions and with positive brake control.

9a.7.3.2 Design Bases

The RF high bay bridge crane does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the crane is classified as nonsafety-related. The following design criterion applies to the design of this crane:

- DC 2, Design Bases for Protection Against Natural Phenomena: The crane is designed to ensure that safety-related SSCs are protected from the adverse consequences of failure of those SSCs not specifically designated as safety-related.

9a.7.3.3 System Evaluation

The RF high bay bridge crane is designed to the following relevant codes and standards:

- Crane Manufacturers Association of America (CMAA) Standard CMAA 70, Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes (CMAA, 2020).
- ASME B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist) (ASME, 2022).

Consistent with Subsection 3.5.2.3, the support structure for the RF high bay crane is designed to avoid failure that would adversely impact safety-related SSCs due to the extreme environmental and abnormal events (satisfies DC 2).

Crane movement is managed through administrative and operational restrictions. Crane load movement over the reactor/pool and transfer canal is prohibited during reactor operation. The crane is designed to allow movement of authorized loads within the RF high bay, including loads over the pool and fueled reactor, based on the operational status of the reactor.

9a.7.3.4 Technical Specifications, Testing, and Inspection

The design of the RF high bay bridge crane permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9a.8 REFERENCES

ANSI/ANS, 2000. Fire Protection Program Criteria for Research Reactors, ANSI/ANS-15.17-1981 (R2000), American National Standards Institute, American Nuclear Society, approved 1981, reaffirmed 2000.

ANSI/ASHRAE, 2022. Ventilation and Acceptable Indoor Air Quality, ASHRAE 62.1-2022, American National Standards Institute, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2022.

ASHRAE, 2022. Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings, I-P Edition, ASHRAE 90.1-2022, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2022.

ASME, 2022. Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist), ASME B30.2, American Society of Mechanical Engineers, 2022.

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NFPA, 2024. Life Safety Code, NFPA 101, National Fire Protection Association, 2024.

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NFPA, 2025b. National Fire Alarm and Signaling Code, NFPA 72, National Fire Protection Association, 2025.

Figure 9a.1-1
Reactor Facility High Bay Ventilation System

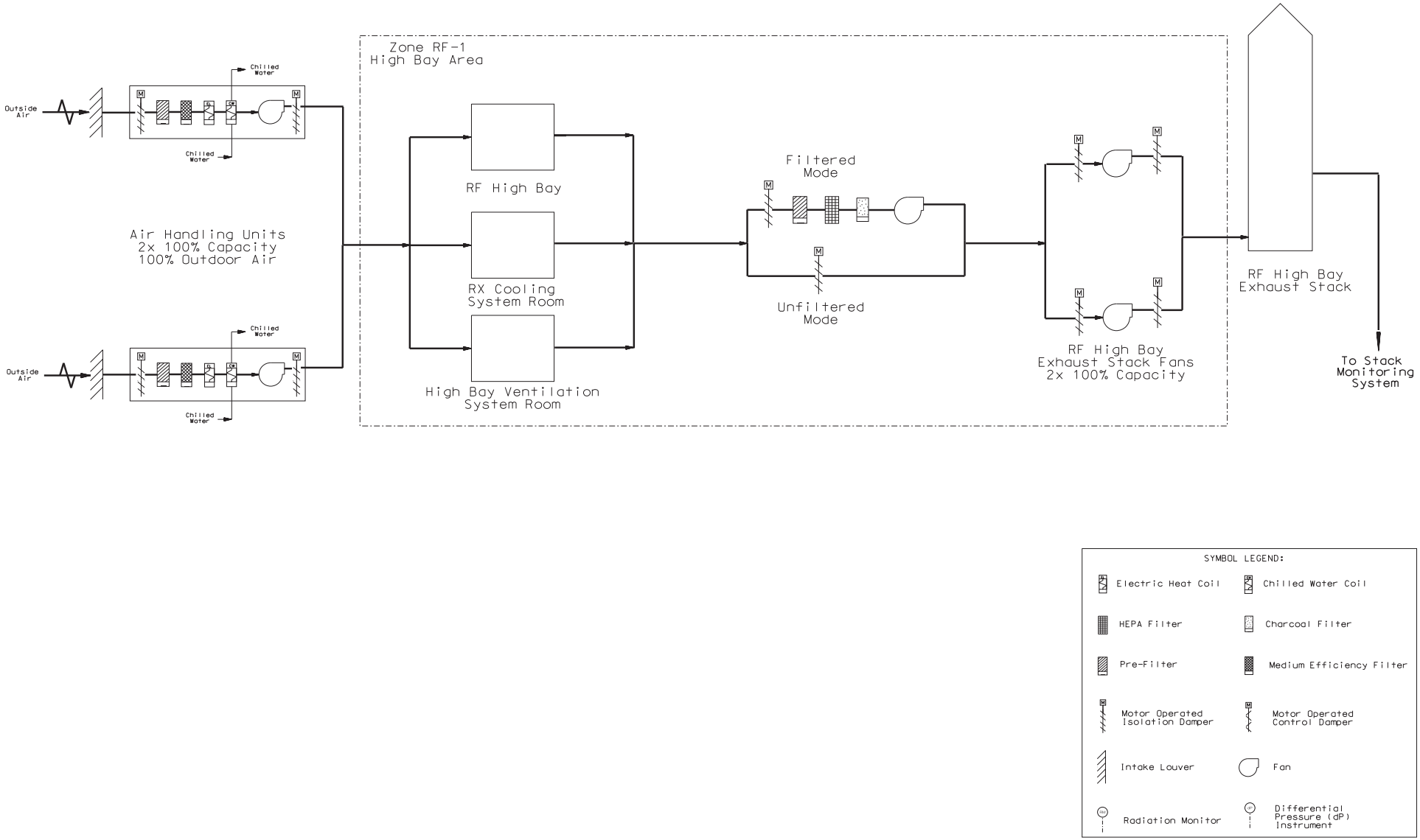

Figure 9a.1-2
Reactor Facility General Area HVAC System

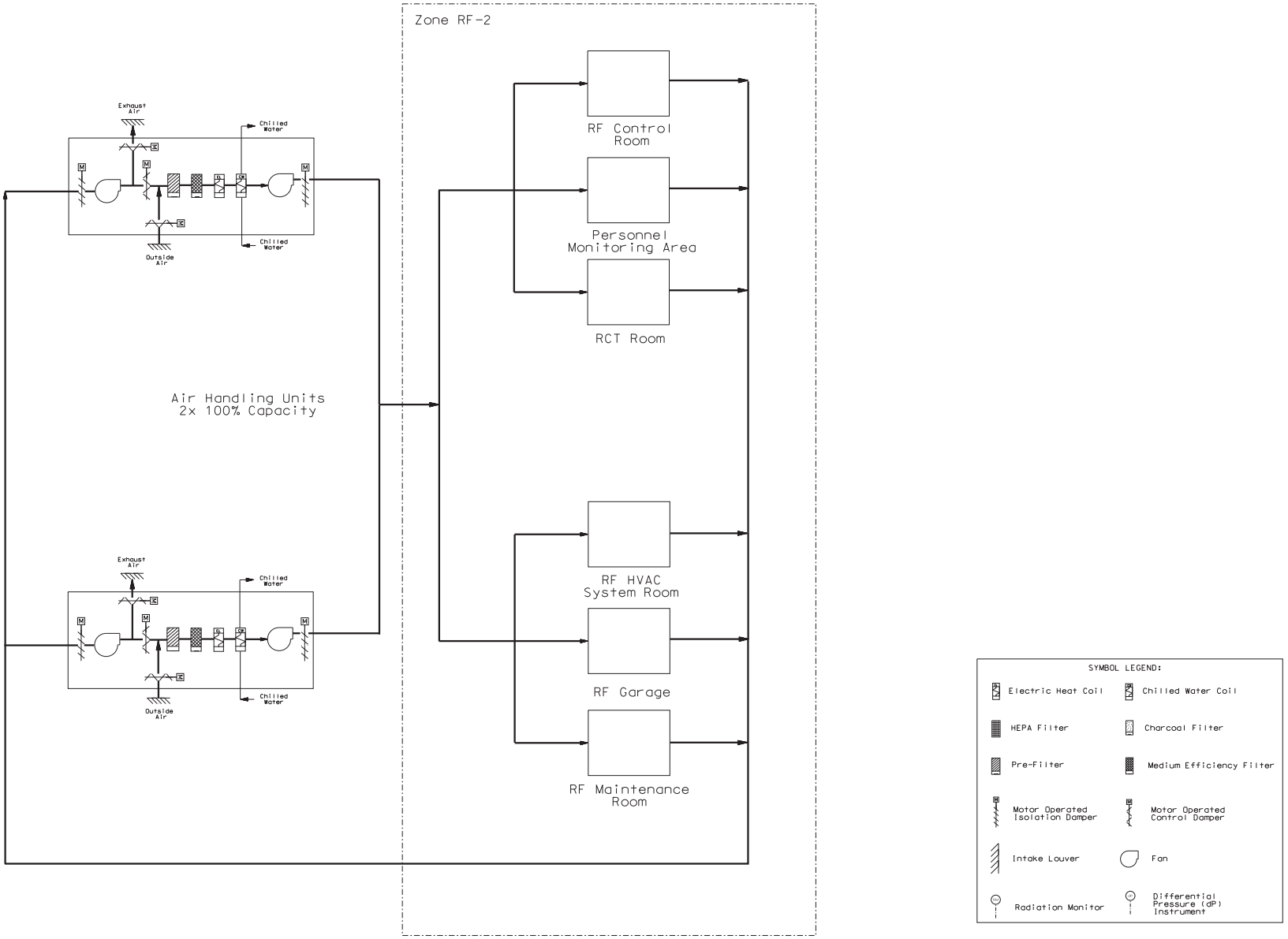

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Figure 9a.2-1
Key Elements of the Target Handling System

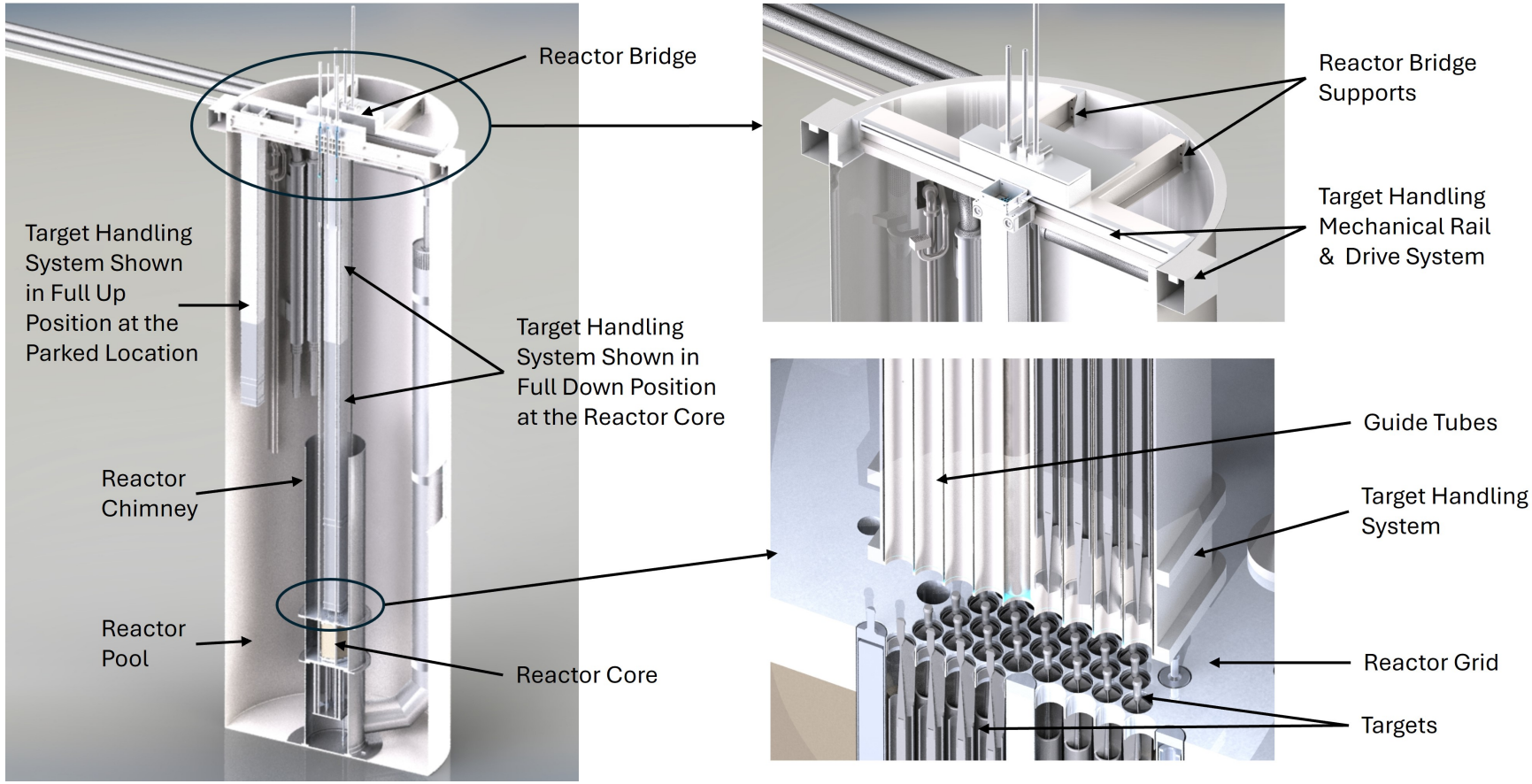

Figure 9a.2-2
Cutaway of Target Handling System Showing Location of Lift Cables

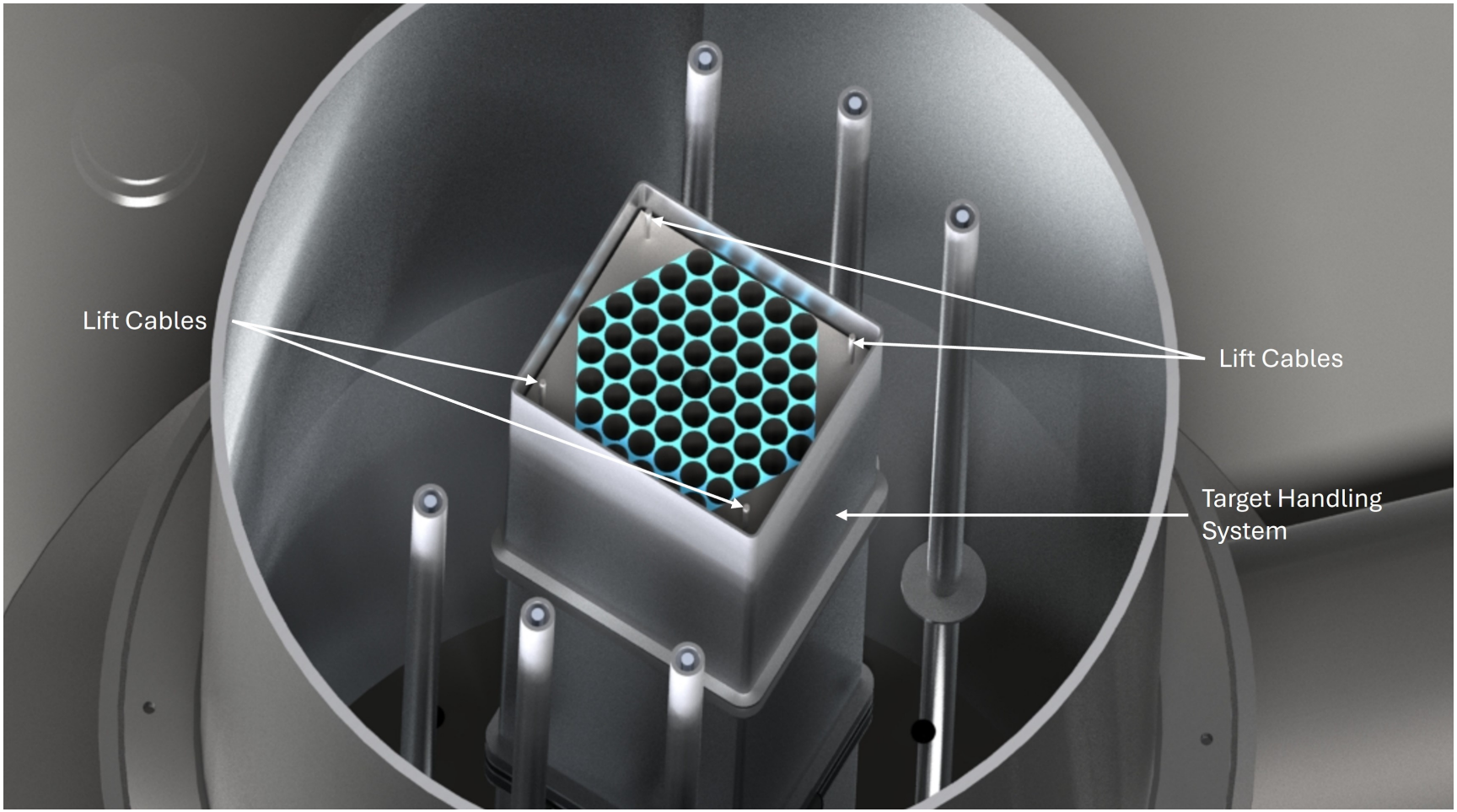

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Figure 9a.2-3
Telescoping Target Handling System Shown in the Full Down Position Over the Reactor Core

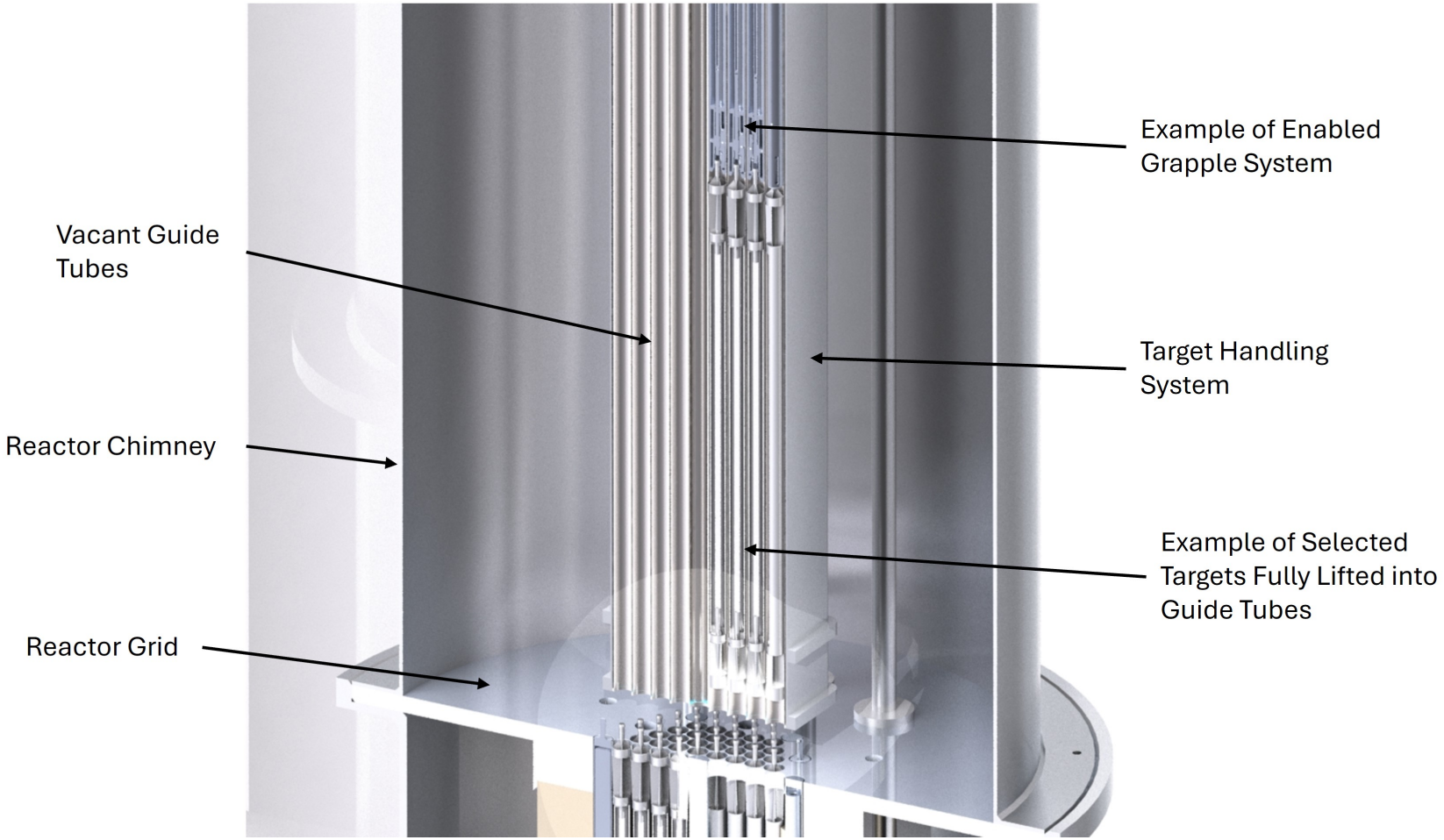

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Figure 9a.2-4
Target Handling System Showing Selected Targets Being Lifted into the Guide Tubes

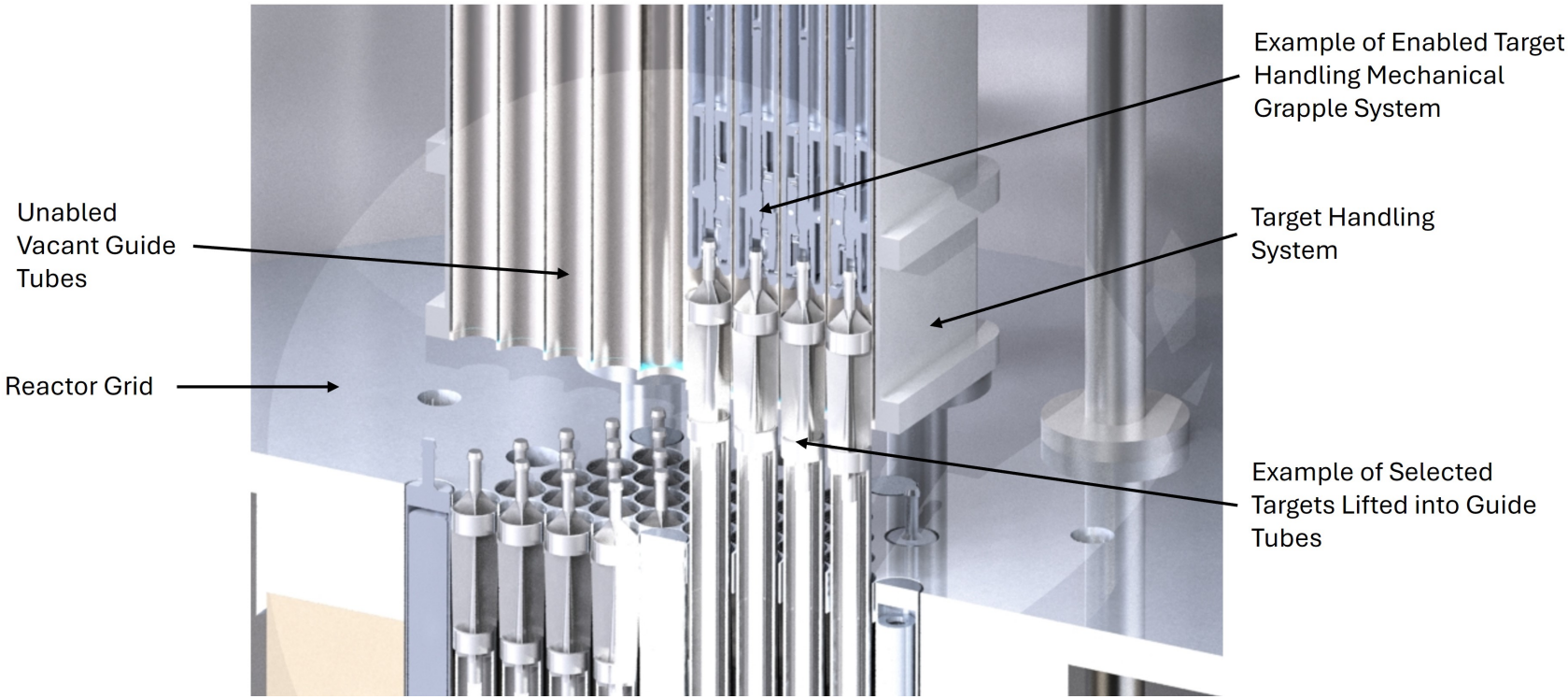

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Figure 9a.2-5
Target Handling System Above the Irradiated Target Transfer Basket

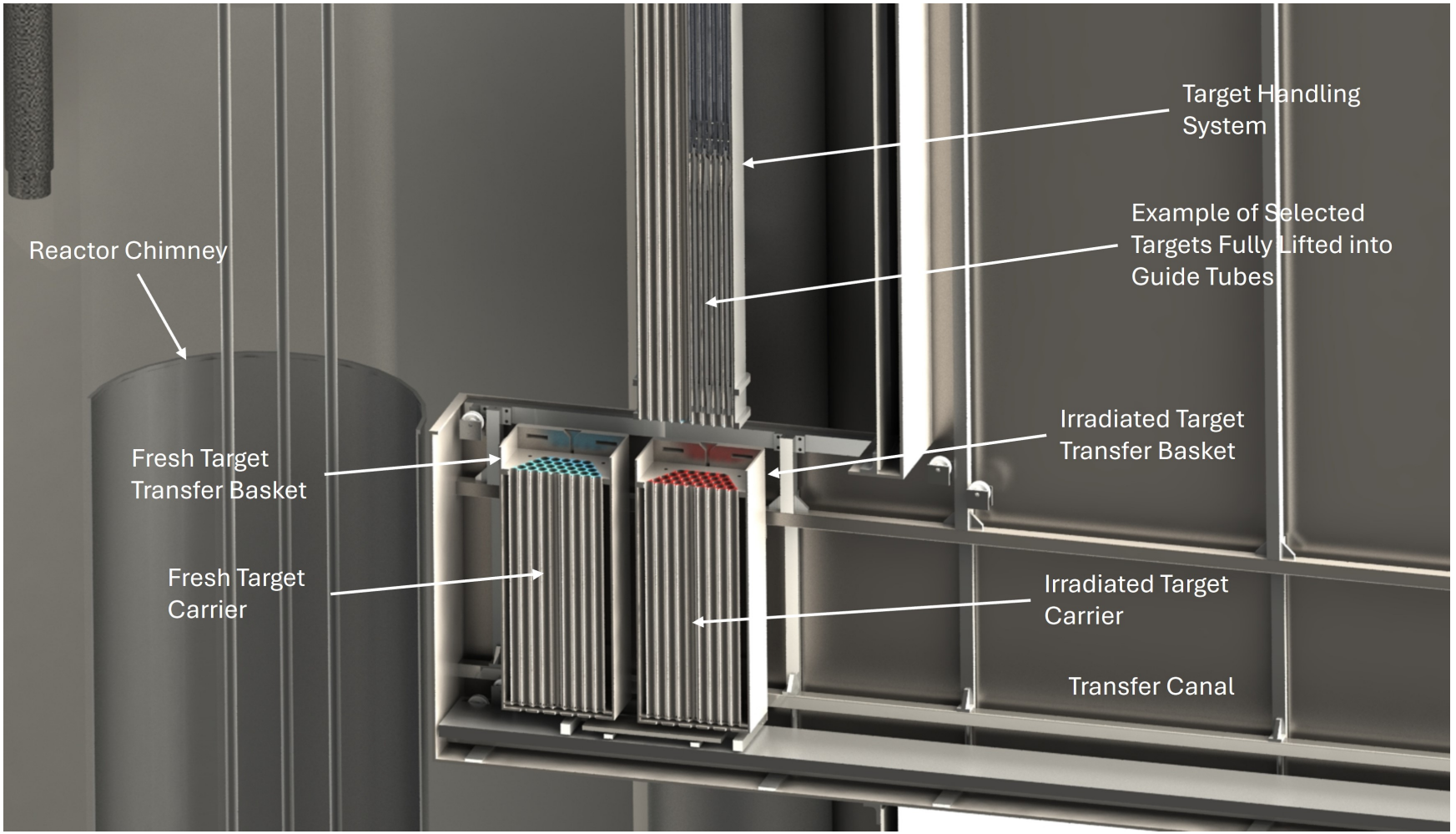

Figure 9a.2-6
Target Handling System Showing Transfer of Irradiated Targets to the Irradiated Target Transfer Basket

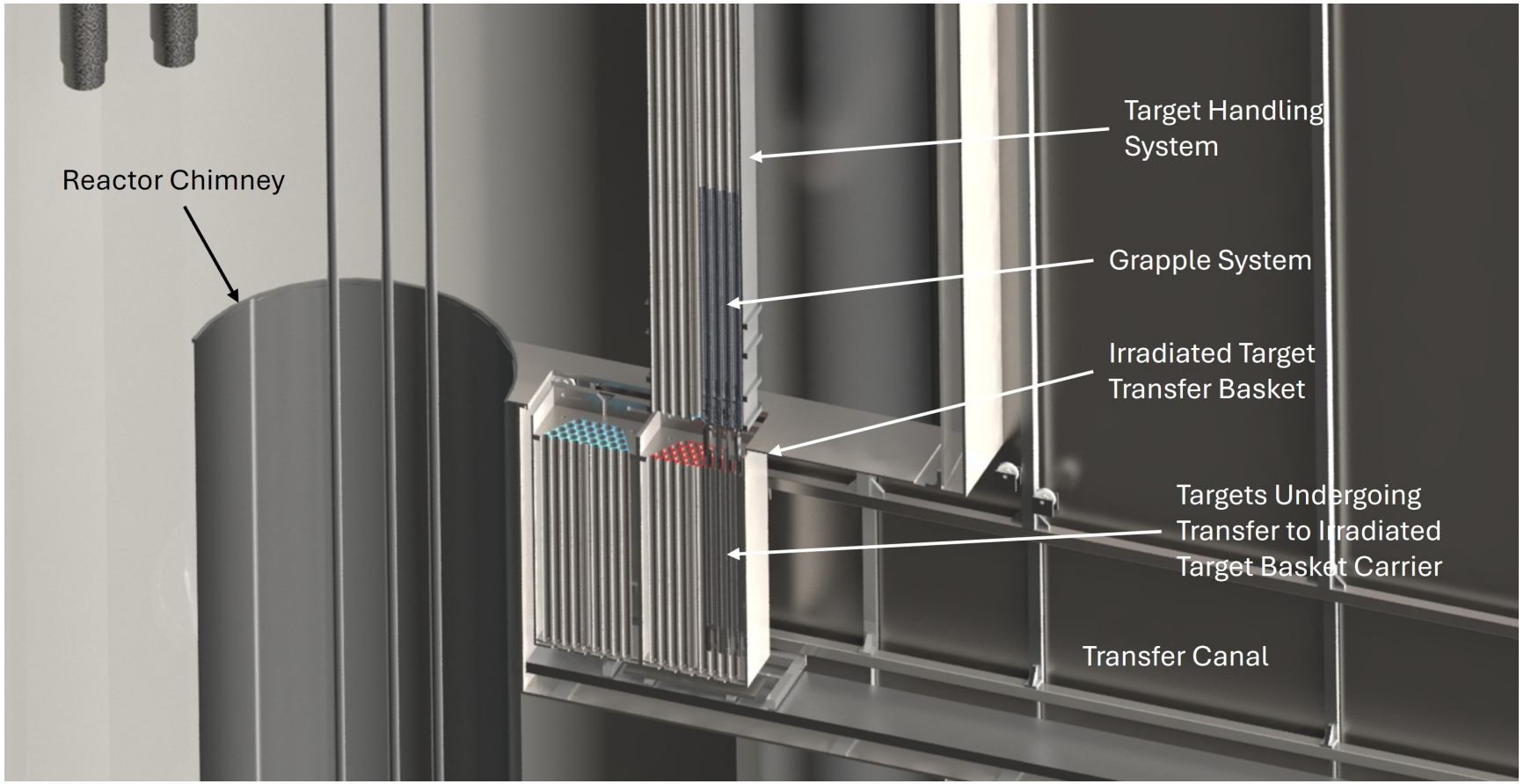

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Figure 9a.2-7
Target Handling System Showing Location of Telescoping Feature Above the Fresh Target Transfer Basket

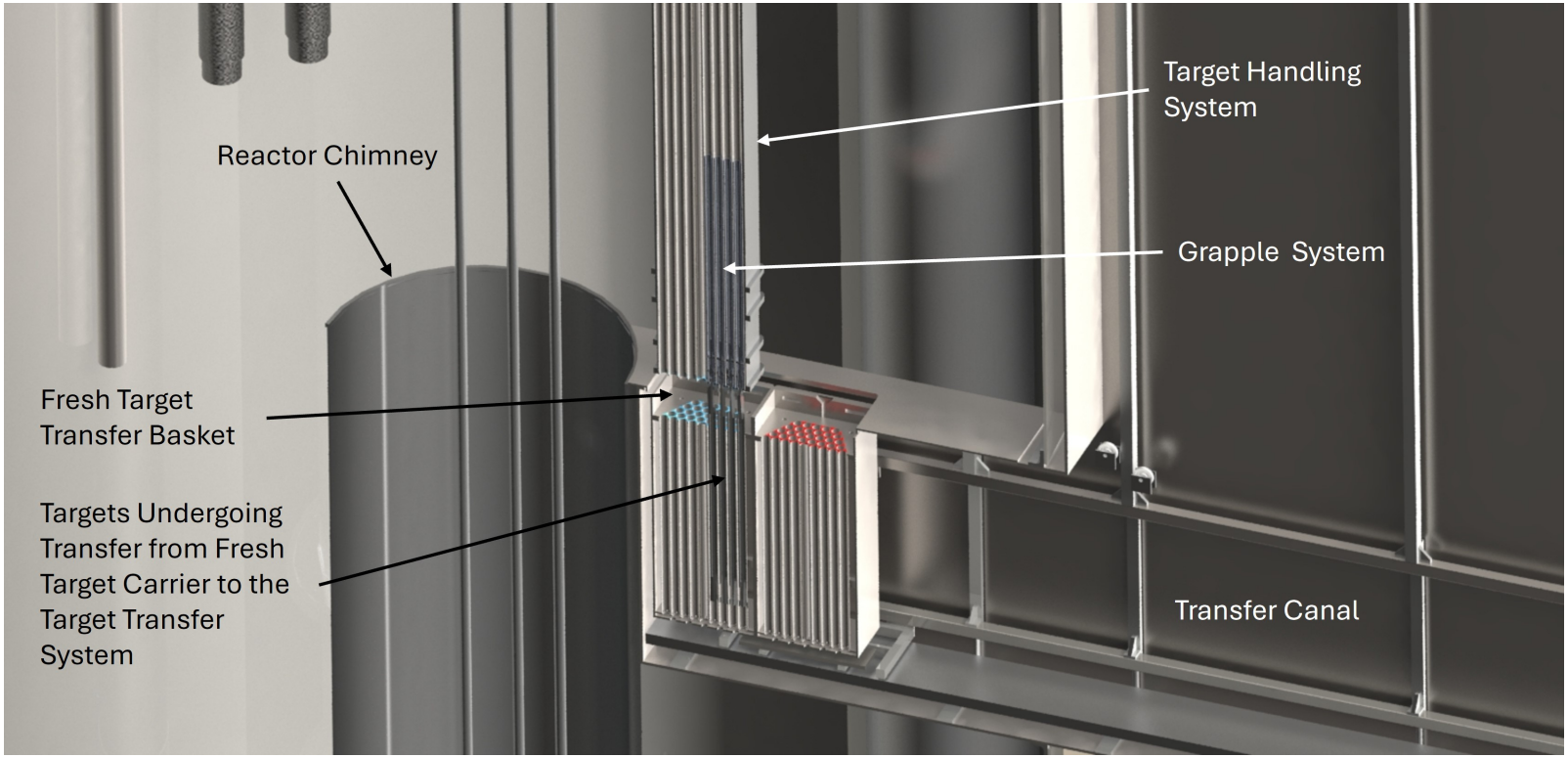

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Figure 9a.2-8
Key Elements of the Target Transfer System

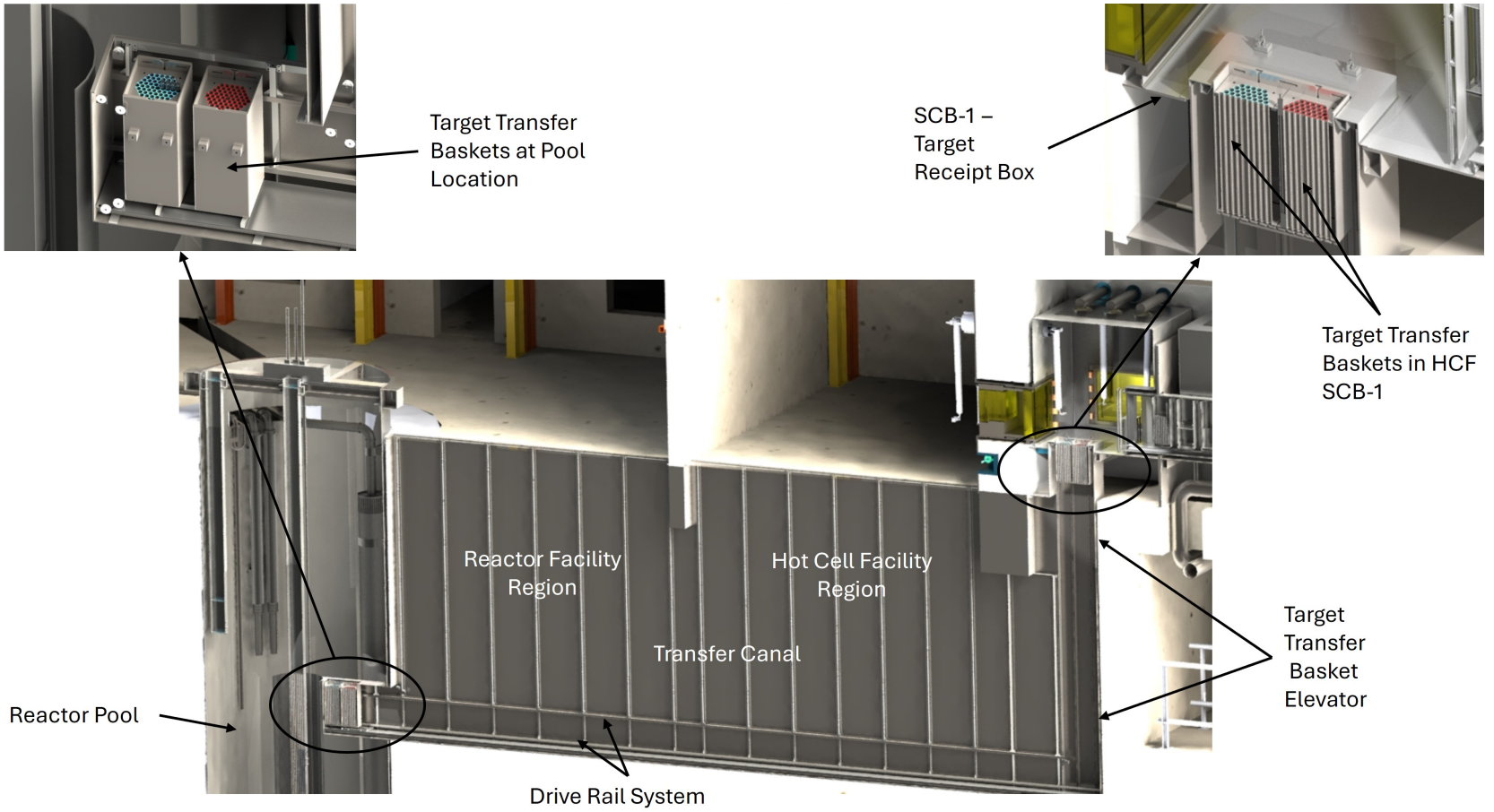

Figure 9a.2-9
Target Transfer System at RF Pool Showing Target Transfer Baskets and Carriers

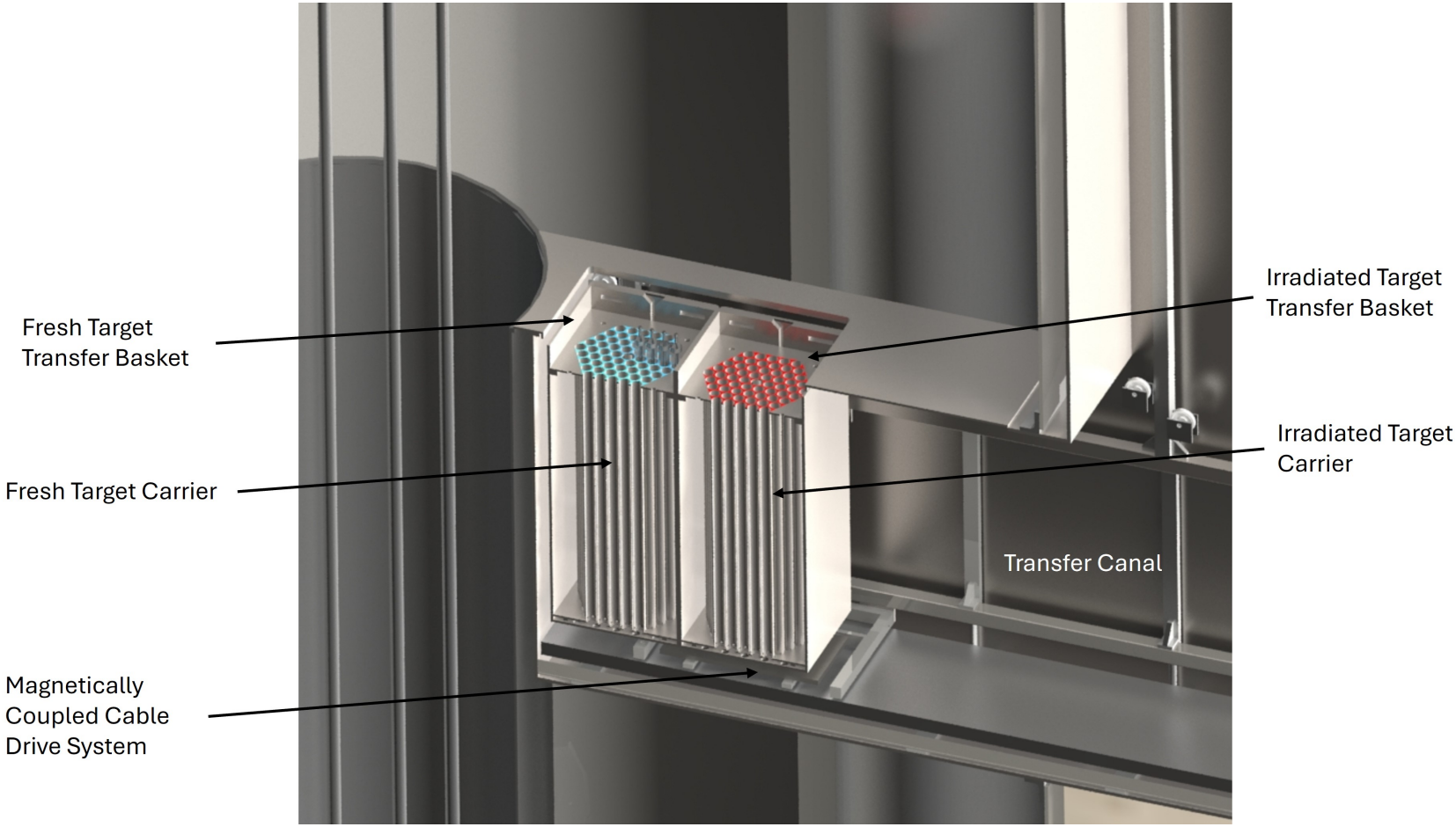

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Figure 9a.2-10
Target Transfer Baskets Raised into the HCF Target Receipt Box

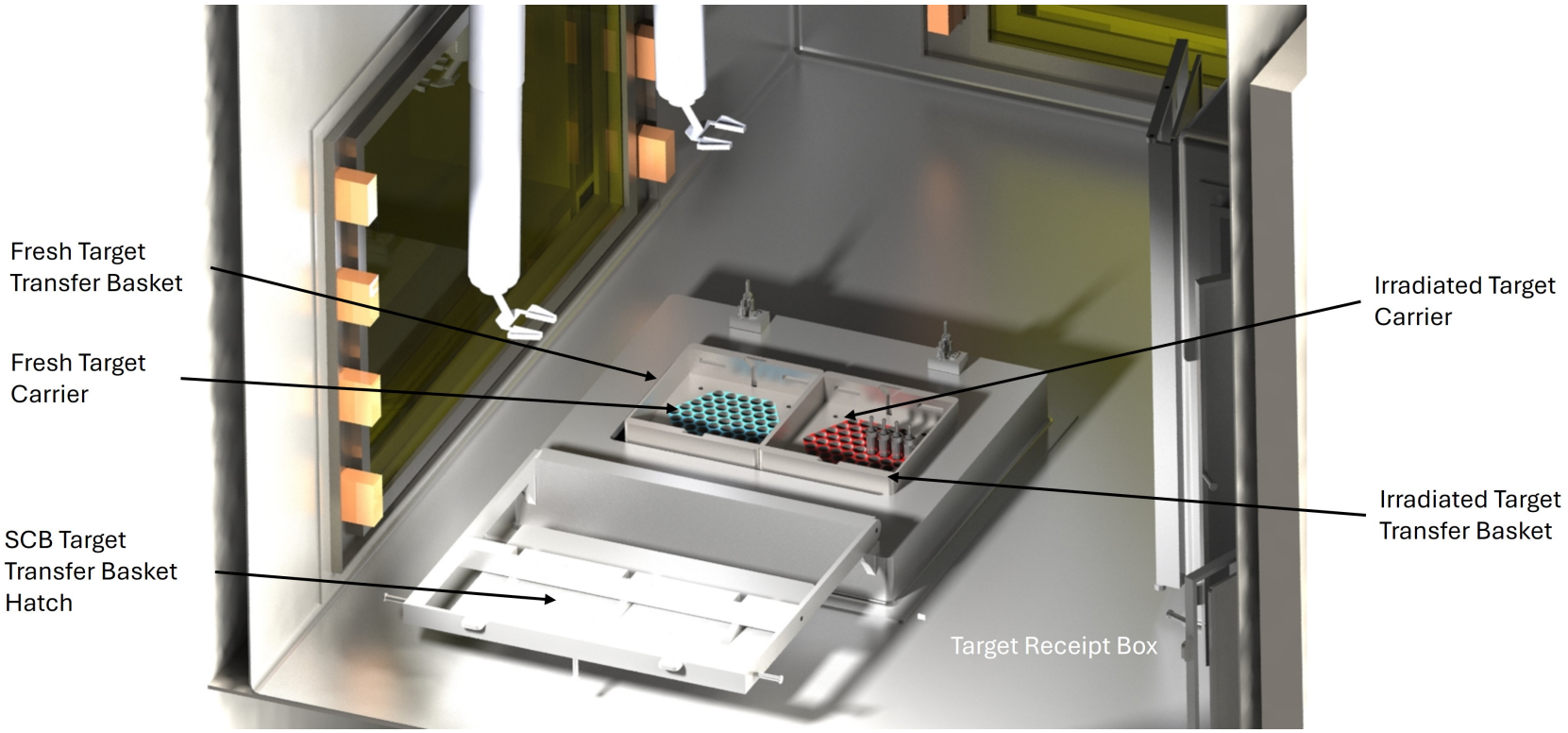

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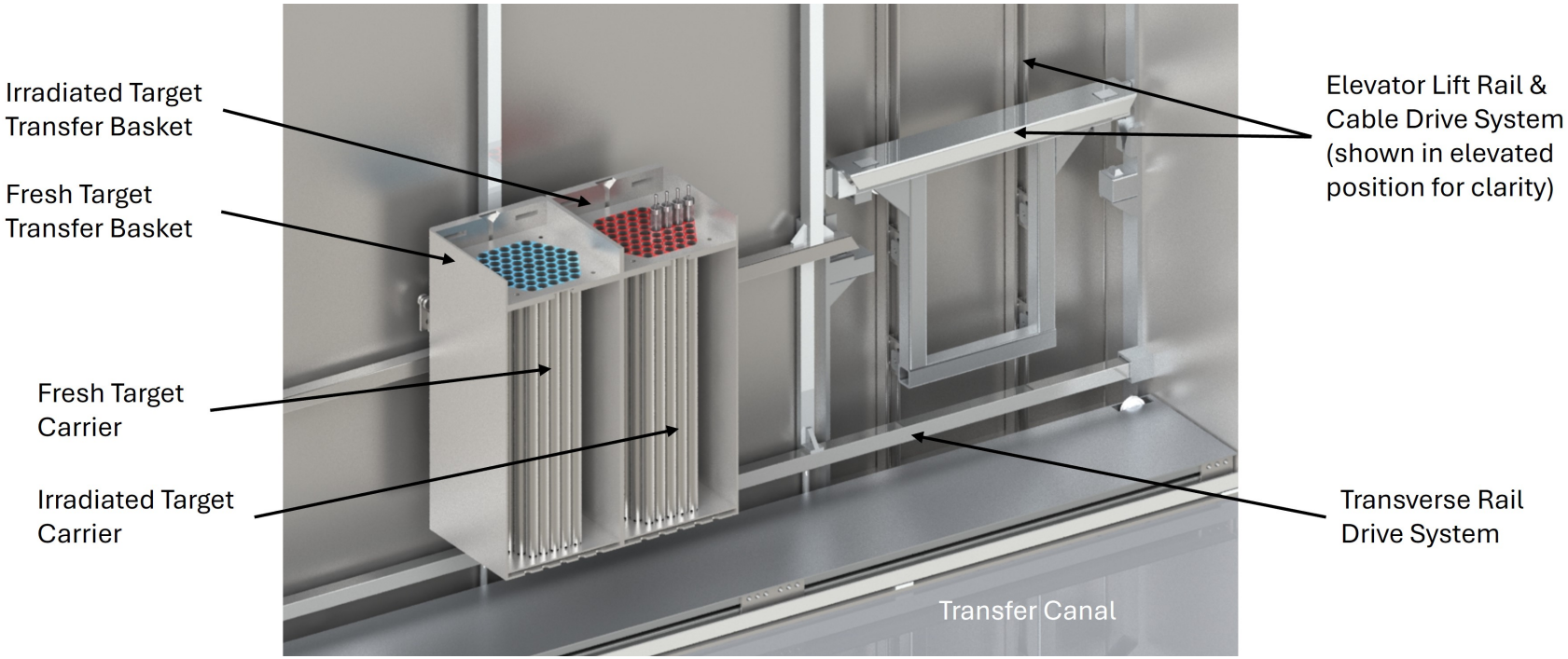
Figure 9a.2-11
Target Transfer Baskets and Elevator System in the Transfer Canal Underneath the HCF Target Receipt Box



Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 9b
Radioisotope Production Facility Auxiliary Systems

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CHAPTER 9b

RADIOISOTOPE PRODUCTION FACILITY AUXILIARY SYSTEMS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AHU	air-handling unit
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
CMAA	Crane Manufacturers Association of America
DC	design criterion(a)
EMIF	Eden Medical Isotope Facility
ESF	Engineered Safety Features
HCF	Hot Cell Facility
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilation, and air conditioning
k_{eff}	effective neutron multiplication factor
LEU	low-enriched uranium
LN2	liquid nitrogen
RCA	radiologically controlled area
SCB	steel confinement box
SNM	special nuclear material
SSC	structure(s), system(s), and component(s)

9b. Radioisotope Production Facility Auxiliary Systems

This chapter provides an overview description of the auxiliary systems at the Eden Medical Isotope Facility (EMIF), specifically for the Hot Cell Facility (HCF). Auxiliary systems are those systems not previously described elsewhere in this Preliminary Safety Analysis Report. The sections that follow provide a description of each auxiliary system, its design basis, and a discussion of the capability to function as designed without compromising facility operation or the capability to safely shut down the facility.

Auxiliary systems addressed in this chapter are:

- Heating, ventilation, and air conditioning (HVAC) systems.
- Handling and storage of reactor fuel.
  - Target transfer system.
  - Material transfer system.
- Fire protection system and program.
- Communication system.
- Systems for the possession and use of byproduct, source, and special nuclear material (SNM).
- Cover gas control systems.
- Liquid nitrogen processing system.
- Cranes.

9b.1 HEATING, VENTILATION, AND AIR CONDITIONING SYSTEMS

9b.1.1 HCF VENTILATION SYSTEM

The HCF ventilation system (see Figure 9b.1-1) is comprised of both safety-related and nonsafety-related portions. The radiologically controlled area (RCA) of the HCF is serviced by a safety-related ventilation system (HCF Zone 1a) and a nonsafety-related ventilation system (HCF Zones 1b, 1c, 1d, 2, and 3).

The safety-related system information including specific safety-related/Engineered Safety Feature (ESF) system description and requirements can be found in Chapter 6b. This section addresses the nonsafety-related structures, systems, and components (SSCs).

9b.1.1.1 System Description

The HCF ventilation system provides the heating, cooling, and ventilation needed to condition the air and maintain radiological confinement in the HCF. The system services the various steel confinement boxes (SCBs), the HCF target processing canyon, the waste storage canyon, the waste transfer shafts (A/B), the occupied portions of the radiological areas, the glovebox and activation processing cells, the fume hoods, and the HCF mechanical equipment rooms. The system is comprised of a once-through ventilation portion, which includes the necessary monitoring and filtration to inhibit the spread of radionuclides. HCF Zones 1-3 are at cascading

negative pressures such that air flow is always maintained from a potentially lower contamination area to a potentially higher contamination area (see Figure 9b.1-2).

All systems are serviced by the chilled water system (i.e., closed-loop cooling using an air-cooled chiller) to meet the cooling demand. Additionally, the systems utilize electric heat in the air-handling units (AHUs) to meet heating demands.

The HCF ventilation system performs the following functions:

- Maintains environmental conditions (e.g., air quality, temperature, humidity, pressure).
- Maintains negative pressure within the HCF zones.
- Directs all exhaust air to the environment through either the HCF Zone 1a exhaust stack or the HCF exhaust stack.
- Monitors the airborne radioactivity in the filtered air that is exhausted through the HCF exhaust stack.

The HCF ventilation system services HCF Zones 1a, 1b, 1c, 1d, 2, and 3. The system is a once-through ventilation system consisting of fans, duct work, dampers, AHUs, and filtration and draws supply air from the outside atmosphere. Outside air is filtered and heated or cooled in the three (3) x 50 percent capacity AHUs and directed to HCF Zones 2 and 3. HCF Zone 1a and HCF Zone 1b receive transfer air from HCF Zone 2.

All zones contain two redundant filter trains and exhaust fans to control the flow and maintain a negative zone pressure. The exhaust air from HCF Zone 1a is directed to its own HCF Zone 1a exhaust stack, as described in Chapter 6b. Exhaust air from HCF Zones 1b, 1c, 1d, 2, and 3 is combined in a downstream header where it is directed to one last set of redundant filters (pre-filter and high-efficiency particulate air [HEPA] filter) and exhaust fans before being sent to the main HCF exhaust stack.

Each zone services the following:

- HCF Zone 1a serves SCBs 2 – 7.
- HCF Zone 1b serves SCBs 1 and 8 – 19.
- HCF Zone 1c serves the glovebox and activation processing cells.
- HCF Zone 1d serves the fume hoods.
- HCF Zone 2 serves the target processing canyon, waste storage canyon, and the waste transfer shafts (A/B).
- HCF Zone 3 serves the worker occupied RCAs.

9b.1.1.2 Design Bases

A portion of the HCF ventilation system (i.e., HCF Zone 1a) is safety-related and supports ESF functions that are discussed further in Chapter 6b. This portion is required to function for the range of conditions from normal operation through accident conditions. The boundary of the safety-related system is shown on Figure 9b.1-1.

All other portions of the HCF ventilation system (i.e., HCF Zones 1b, 1c, 1d, 2, and 3) do not perform safety-related functions and are not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Those portions are classified as nonsafety-related.

The following design criteria (DC) apply to the design of the nonsafety-related portion of this system:

- DC 8, Instrumentation and Control: The HCF ventilation system includes instrumentation to monitor variables and systems over their anticipated ranges during normal operation, anticipated operational occurrences, and accident conditions as appropriate to ensure adequate safety, including those variables and systems that can affect the confinement and its associated systems. Appropriate controls are provided to maintain these variables and systems within prescribed operating ranges.
- DC 10, Confinement: The HCF ventilation system is designed to support the establishment of low-leakage barriers against uncontrolled releases of radioactivity to the rest of the facility and the environment and to ensure that the released effluent from the HCF is filtered and discharged through the HCF exhaust stack.
- DC 18, Control of Releases of Radioactive Materials to the Environment: The HCF ventilation system is designed to control the release of radioactive material in gaseous effluents during normal production operation, anticipated operational occurrences, and accident conditions.
- DC 21, Monitoring Radioactivity Releases: The HCF ventilation system is designed to provide for monitoring the HCF area effluent discharge paths for radioactivity that may be released during normal production operation, anticipated operational occurrences, and accident conditions.

9b.1.1.3 System Evaluation

The HCF ventilation system is designed to local building codes and the following relevant codes and standards:

- American Society of Mechanical Engineers (ASME) AG-1, Code on Nuclear Air and Gas Treatment (ASME, 2023).
- American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) 62.1-2022, Ventilation and Acceptable Indoor Air Quality (American National Standards Institute [ANSI]/ASHRAE, 2022).
- ASHRAE 90.1-2022 Energy Standard for Buildings Except Low-Rise Residential Buildings, I-P Edition (ASHRAE, 2022).
- ANSI/ASME N509-2002, Nuclear Power Plant Air-Cleaning Units and Components (R2008) (ANSI/ASMI, 2008).
- ANSI/ASME N510-2007, Testing of Nuclear Air Treatment Systems (ANSI/ASME, 2007).

The HCF ventilation system is designed to support the setup of low-leakage barriers against uncontrolled releases of radioactivity by establishing a negative pressure within the specified zones and ensures released effluent from the HCF is filtered and discharged through either the HCF Zone 1a exhaust stack or the HCF exhaust stack. This satisfies the requirements of DC

10. The system includes appropriate instrumentation and controls to satisfy the requirements of DC 8.

The HCF ventilation system is designed to control the release of radioactive material in gaseous effluents during normal production operation through filtered and monitored release paths. This satisfies the requirements of DC 18.

The discharge pathways for all portions of the HCF ventilation system are monitored for radioactivity during normal production operation and from postulated accidents. The monitoring satisfies DC 21.

9b.1.1.4 Technical Specifications, Testing, and Inspection

The design of the HCF ventilation system permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification for the nonsafety-related portions of the HCF HVAC system.

9b.1.2 HCF GENERAL AREA HVAC SYSTEM

9b.1.2.1 System Description

The HCF general area HVAC system (i.e., HCF Zone 4) is a recirculated air ventilation system consisting of fans, duct work, dampers, AHUs, and filtration that mixes return air and outside air (see Figure 9b.1-3). It utilizes redundant AHUs to condition the mixture of outside and return air from HCF Zone 4 areas. Exhaust/relief air is controlled by motorized dampers to maintain a constant neutral pressure relative to the atmosphere.

The system is serviced by the chilled water system (i.e., closed-loop cooling using an air-cooled chiller) to meet the cooling demand. Additionally, the system utilizes electric heat in the AHUs to meet heating demands.

9b.1.2.2 Design Bases

The HCF general area HVAC system does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the system is classified as nonsafety-related.

There are no specific design criteria that apply to this system.

9b.1.2.3 System Evaluation

The HCF general area HVAC system is designed to local building codes and the following relevant codes and standards:

- ASHRAE 62.1-2022 (ANSI/ASHRAE, 2022).
- ASHRAE 90.1-2022 (ASHRAE, 2022).

9b.1.2.4 Technical Specifications, Testing, and Inspection

The design of the HCF general area HVAC system permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9b.2 HANDLING AND STORAGE OF REACTOR FUEL

9b.2.1 HOT CELL TARGET TRANSFER SYSTEM

Assembled, fresh (unirradiated) targets that have passed the quality control requirements are stored in the SNM storage area in a criticality-safe storage rack. These targets are fully assembled, uniquely identified, and ready for irradiation. The storage rack design will be presented in the Operating License Application. The rack is designed to hold several hundred targets and remains in a criticality safe condition, even when flooded.

The following DC applies to the criticality-safe storage rack:

- DC 20, Criticality Control: Criticality is prevented by the design of the physical system using geometrically safe configurations.

Up to 60 targets can be transferred from the SNM storage area to the target receipt box for transfer to the reactor pool through the transfer canal. The target transfer system that moves targets from the target receipt box through the transfer canal is discussed in Section 9a.2.

Fresh target transfer occurs on an as needed basis as the irradiated targets are processed. Assuming 20 targets are processed on a weekly basis, a fresh target transfer of 60 targets would occur every three weeks.

A fresh target carrier designed to hold 60 targets and maintain the same pitch as the reactor core is used to move the fresh targets from the SNM storage area to the target receipt box. The fresh target carrier, shown in Figure 9b.2-1, is fabricated using stainless-steel tubes and remains subcritical, even under flooded conditions.

The targets are loaded one at a time in the carrier manually. In air, the fully loaded carrier remains subcritical (i.e., k_{eff} [the effective neutron multiplication factor] less than 0.1). The fresh target carrier is placed on a cart, loaded with uniquely identified targets from the SNM storage area, and moved to the target receipt box. An under-box shield drawer is used to move the fresh target carrier into the target receipt box. The under-box shield drawers will be described in the Operating License Application.

The fresh target carrier in the target receipt box is shown in Figure 9b.2-2. In the target receipt box, the fresh target carrier is placed in the fresh target transfer basket located on the elevator of the target transfer system. The fresh target transfer basket is lowered using the elevator and moved through the transfer canal, as described in Section 9a.2.

Irradiated targets are moved from the reactor pool to the target receipt box as described in Section 9a.2. Up to 24 targets can be processed at one time in the dissolver boxes, six per dissolver box. The irradiated targets are removed individually from the irradiated target carrier using the target receipt box remote manipulators. The irradiated target carrier remains in the basket on the elevator. Irradiated targets are staged in the target receipt box in the irradiated target stand as shown in Figure 9b.2-2.

The irradiated targets are examined through the shield window to verify that the correct targets have been removed from the reactor core. The target end flutes and centering rod are removed from the target and the target grouped with others for transfer to the correct dissolver box for disassembly and dissolution.

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Details of the HCF target transfer system will be further defined in the Operating License Application.

9b.2.2 SCB MATERIAL TRANSFER SYSTEM

Chapter 4b describes the HCF and process description, including the irradiated target processing steps performed in the HCF target processing canyon.

9b.3 FIRE PROTECTION SYSTEM AND PROGRAM

Information on fire protection system and program for the HCF is contained in Section 9a.3.

9b.4 COMMUNICATION SYSTEM

Information on the communication system for the HCF is contained in Section 9a.4.

9b.5 POSSESSION AND USE OF BYPRODUCT, SOURCE, AND SPECIAL NUCLEAR MATERIAL

Information on possession and use of byproduct, source, and SNM for the HCF is contained in Section 9a.5.

9b.6 COVER GAS CONTROL IN CLOSED PRIMARY COOLANT SYSTEM

Information on the primary coolant system is described in Section 9a.6.

9b.7 OTHER AUXILIARY SYSTEMS

The following subsections provide descriptions and functional requirements of other auxiliary systems. These other auxiliary systems include:

- Cranes.
  - HCF target processing high bay bridge crane.
  - HCF target processing canyon support crane.
  - HCF target fabrication area bridge crane.
  - HCF cask loading bay cranes (A/B).
- Liquid nitrogen processing systems.

9b.7.1 CRANES

9b.7.1.1 HCF Target Processing High Bay Bridge Crane

9b.7.1.1.1 System Description

The HCF target processing high bay bridge crane is a top running overhead crane that serves the HCF target processing high bay. The crane is located within the RCA where exposure to radiation may occur and radiological contamination may be present.

The crane is used by HCF personnel to lift, move, and position isotope production facility equipment and support systems. Movement activities facilitate routine service, maintenance, repair, test, and checkout of highly valuable support equipment and hardware including radiation shield windows, manipulators, empty waste drums and carts, SCBs, processing equipment, and specialty tools and fixtures.

The crane is operated manually by HCF operations personnel using a pendant or a radio control. The crane operation includes provisions to control hoist and bridge/trolley speeds and limits with positive brake controls.

9b.7.1.1.2 Design Bases

The HCF target processing high bay bridge crane does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the crane is classified as nonsafety-related.

There are no specific design criteria that apply to this system.

9b.7.1.1.3 System Evaluation

The HCF target processing high bay bridge crane is designed to the following relevant codes and standards:

- Crane Manufacturers Association of America (CMAA) Standard CMAA 70, Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes (CMAA, 2020).

- ASME B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist) (ASME, 2022).

Crane movement is managed through administrative and operational restrictions. Crane load movement in areas directly above the HCF target processing canyon is prohibited except when needed to perform authorized movements supporting operational setup, test, and check-out activities as required by HCF operations.

9b.7.1.1.4 Technical Specifications, Testing, and Inspection

The design of the HCF target processing high bay bridge crane permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9b.7.1.2 HCF Target Processing Canyon Support Crane

9b.7.1.2.1 System Description

The HCF target processing canyon support crane is a gantry crane that serves the HCF target processing canyon and is located on the top of the exterior walls of the HCF target processing canyon. The crane is located within the RCA where exposure to radiation may occur, and radiological contamination may be present.

The gantry crane is designed to have sufficient rated load to support removal of the biological shielding roof panels to allow access to the highly radiologically contaminated isotope production processing, purification, packaging, and waste handling systems and components located within the HCF target processing canyon during scheduled maintenance production outage periods. Irradiated isotope production targets and product are cleared from the HCF target processing canyon prior to removal of the biological shielding roof panels.

The crane is operated manually by HCF operations personnel using a pendant or a radio control. The crane operation includes provisions to control hoist and gantry/trolley speeds and limits with positive brake controls.

9b.7.1.2.2 Design Bases

The HCF target processing canyon support crane does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, the crane is classified as nonsafety-related. The following design criterion applies to the design of this crane:

- DC 2, Design Bases for Protection Against Natural Phenomena: The crane is designed to ensure that safety-related SSCs are protected from the adverse consequences of failure of those SSCs not specifically designated as safety-related.

9b.7.1.2.3 System Evaluation

The HCF target processing canyon support crane is designed to the following relevant codes and standards:

- CMAA 70 (CMAA, 2020).
- ASME B30.2 (ASME, 2022).

Consistent with Subsection 3.5.2.3, the support structure for the HCF target processing canyon support crane is designed to avoid failure that would adversely impact safety-related SSCs due to the extreme environmental and abnormal events (satisfies DC 2).

Crane movement is managed through administrative and operational restrictions. Crane movement over areas directly above the removable roof panels is prohibited except when needed to perform authorized movements supporting operational setup, test, and check-out activities as required by HCF operations.

9b.7.1.2.4 Technical Specifications, Testing, and Inspection

The design of the HCF target processing canyon support crane permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9b.7.1.3 HCF Target Fabrication Area Bridge Crane

9b.7.1.3.1 System Description

The HCF target fabrication area bridge crane is a top running overhead crane that serves the HCF target fabrication area. The crane is located within the RCA where exposure to radiation and radiological contamination may be present.

The crane is used by HCF operations to support on-site manufacturing of low-enriched uranium (LEU) metal foil targets and to perform routine maintenance and service on high value foundry equipment. During target production (run) cycles, the crane provides operational coverage to move and position high value uranium feedstock materials and equipment needed to produce uranium metal castings and ingots, as well as for precise movements of specialized equipment needed when performing foil rolling, heat treat, forming, and plating processes.

The crane is operated manually by HCF operations personnel using a pendant or a radio control. The crane operation includes provisions to control hoist and bridge/trolley speeds and limits with positive brake controls.

9b.7.1.3.2 Design Bases

The HCF target fabrication area bridge crane does not perform safety-related functions and is not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Furthermore, the crane is located in a separate room on the main floor in the HCF that is solely designated for the fabrication and production of LEU metal foil targets. There are no safety-

related SSCs associated with the activities performed in the target fabrication area, and the crane is separated from other HCF safety-related SSCs. Therefore, the crane is classified as nonsafety-related and non-seismic.

There are no specific design criteria that apply to this system.

9b.7.1.3.3 System Evaluation

The HCF target fabrication area bridge crane is designed to the following relevant codes and standards:

- CMAA 70 (CMAA, 2020).
- ASME B30.2 (ASME, 2022).

Crane movement is managed through administrative and operational restrictions. The HCF target processing canyon support crane is not parked directly over critical LEU metal foil target fabrication materials, systems, or production equipment when not in use.

9b.7.1.3.4 Technical Specifications, Testing, and Inspection

The design of the HCF target fabrication area bridge crane permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9b.7.1.4 HCF Cask Loading Bay Cranes (A/B)

9b.7.1.4.1 System Description

Separate and independent HCF cask loading bay cranes (A/B) serve the two HCF cask loading bays (A/B), which include access to the HCF waste transfer shafts (A/B). The cranes are located within the RCA where exposure to radiation may occur and radiological contamination may be present.

The cranes are top running overhead cranes designed to have sufficient rated load and hook height to support the transfer of highly radioactive waste drums into shipping casks for off-site waste shipments. The cranes are also used to support casks pre- and post-loading operations to include removal, staging, and replacement of hardware as needed to access, load, secure, and complete final packaging validation activities. The cranes may also be used to perform service, maintenance, repair, and test and checkout of cask systems and hardware.

The cranes are operated manually by HCF operations personnel using a pendant or a radio control. The cranes' operation include provisions to control hoist and bridge/trolley speeds with soft start and stop functions and with positive brake control.

9b.7.1.4.2 Design Bases

The HCF cask loading bay cranes (A/B) do not perform safety-related functions and are not credited for the mitigation of postulated accidents or to perform safe shutdown functions. Therefore, both cranes are classified as nonsafety-related.

There are no specific design criteria that apply to this system.

The cranes are designed to allow movement of authorized radioactive loads within the cask loading bays (A/B) and therefore are designed to operate in high radiation areas. The crane incorporates radiation hardened or protected (shielded) controls to support precise movements in both staffed and unstaffed operations.

9b.7.1.4.3 System Evaluation

The HCF cask loading bay cranes (A/B) are designed to the following relevant codes and standards:

- CMAA 70 (CMAA, 2020).
- ASME B30.2 (ASME, 2022).

Crane movement is managed through administrative and operational restrictions. Crane load movements in areas directly above waste transfer shafts (A/B) are prohibited except when needed to perform authorized movement of waste drums and equipment during cask loading. Authorized movements may also include other operational setup and test and check-out activities as required by HCF operations.

9b.7.1.4.4 Technical Specifications, Testing, and Inspection

The design of the HCF cask loading bay cranes permits routine testing and inspection without disruption to normal operation. Testing is performed on an appropriate basis to detect and correct any problems or degradation of the components.

There are no potential variables, conditions, or other items that are probable subjects of a technical specification.

9b.7.2 LIQUID NITROGEN PROCESSING SYSTEMS

Liquid nitrogen (LN2) is used in the HCF during isotope processing. A bulk storage tank is located on-site near the EMIF. An underground insulated pipeline or portable dewars are used to bring LN2 into the HCF as needed to support processing.

9b.8 REFERENCES

ANSI/ASHRAE, 2022. Ventilation and Acceptable Indoor Air Quality, ASHRAE 62.1-2022, American National Standards Institute, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2022.

ANSI/ASME, 2007, Testing of Nuclear Air Treatment Systems, ANSI/ASME N510-2007, American National Standards Institute, American Society of Mechanical Engineers, 2007.

ANSI/ASME, 2008. Nuclear Power Plant Air-Cleaning Units and Components, ASME N509-2002 (R2008), American National Standards Institute, American Society of Mechanical Engineers, issued 2002, reaffirmed 2008.

ASHRAE, 2022. Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings, I-P Edition, ASHRAE 90.1-2022, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2022.

ASME, 2022. Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist), ASME B30.2, American Society of Mechanical Engineers, 2022.

ASME, 2023. Code on Nuclear Air and Gas Treatment, ASME AG-1, American Society of Mechanical Engineers, 2023.

CMAA, 2020. Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes, CMAA 70-2020, Crane Manufacturers Association of America, 2020.

Figure 9b.1-1
Hot Cell Facility Ventilation System (Zones 1-3)

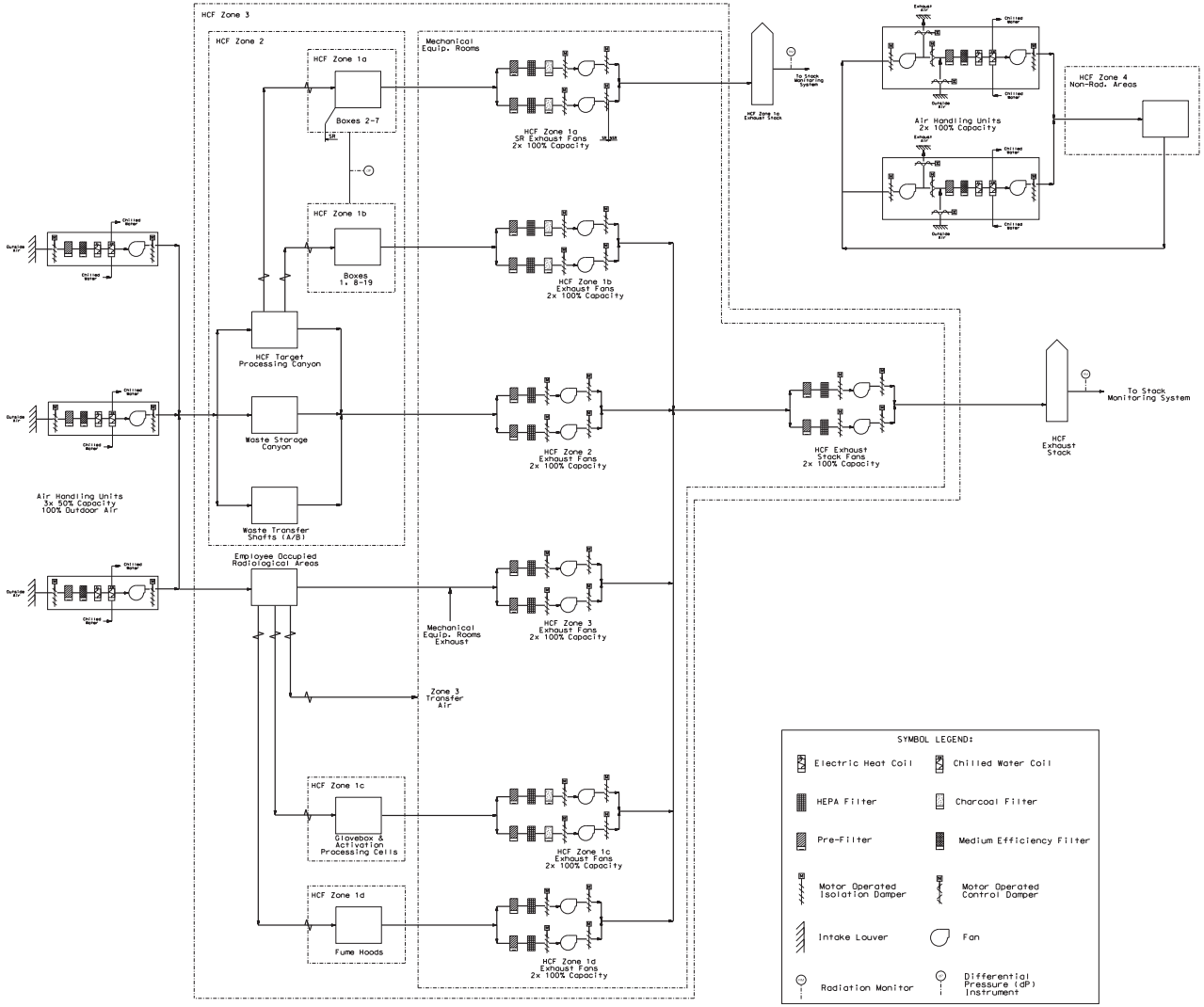

Figure 9b.1-2
Hot Cell Facility Zone System

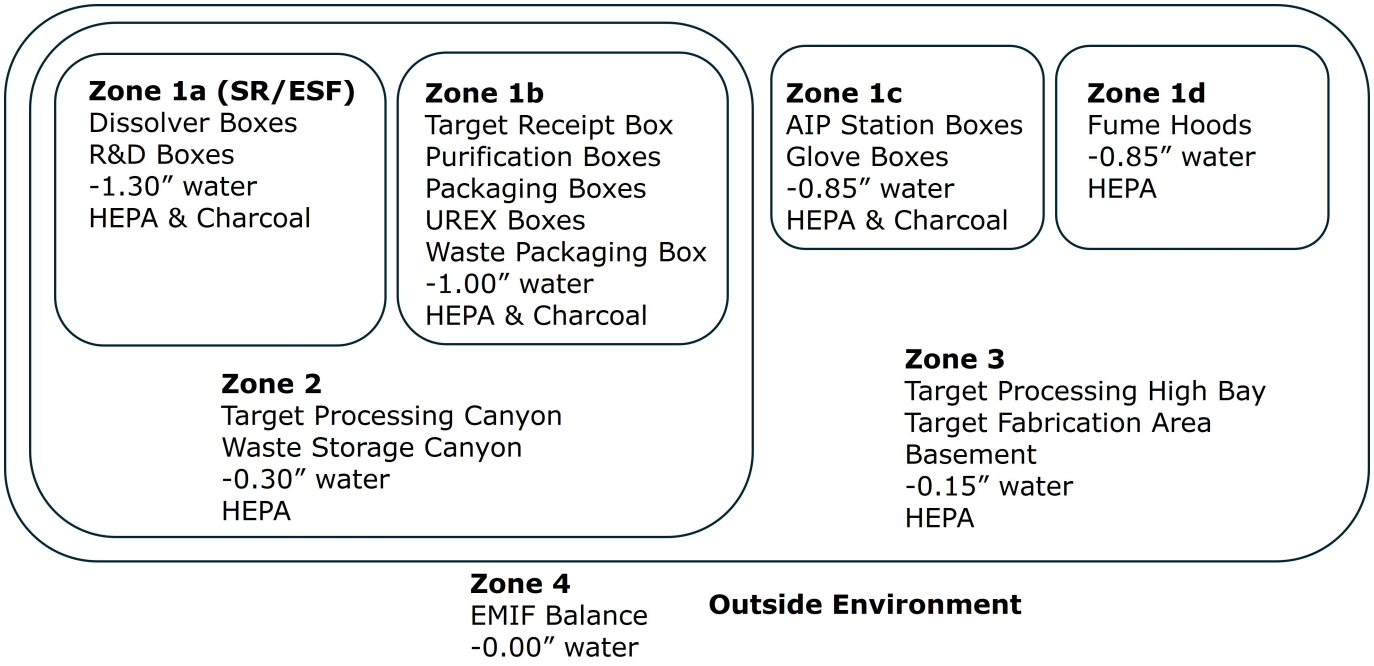

Figure 9b.1-3
Hot Cell Facility General Area HVAC System (Zone 4)

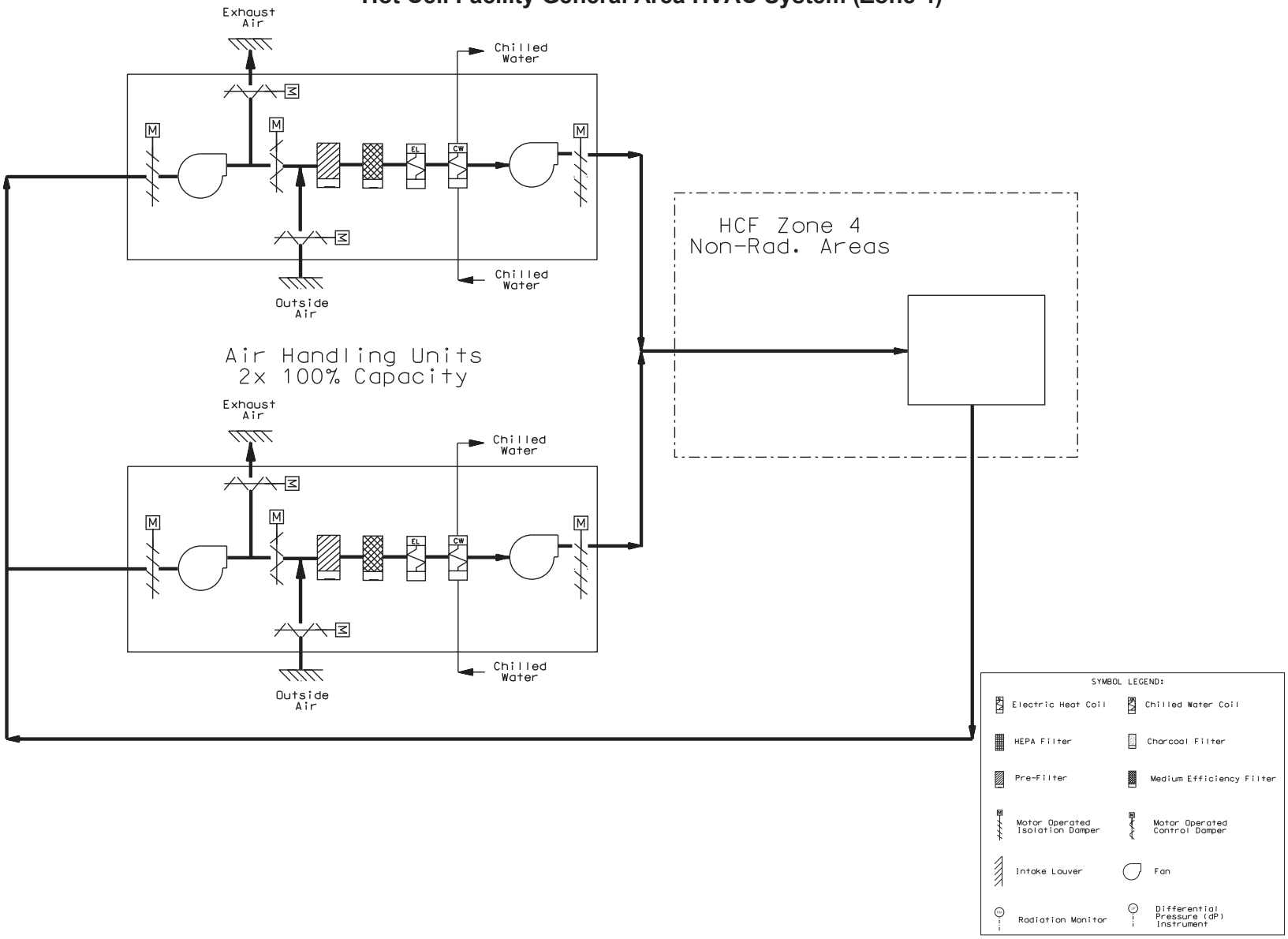

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Figure 9b.2-1
Fresh Target Carrier

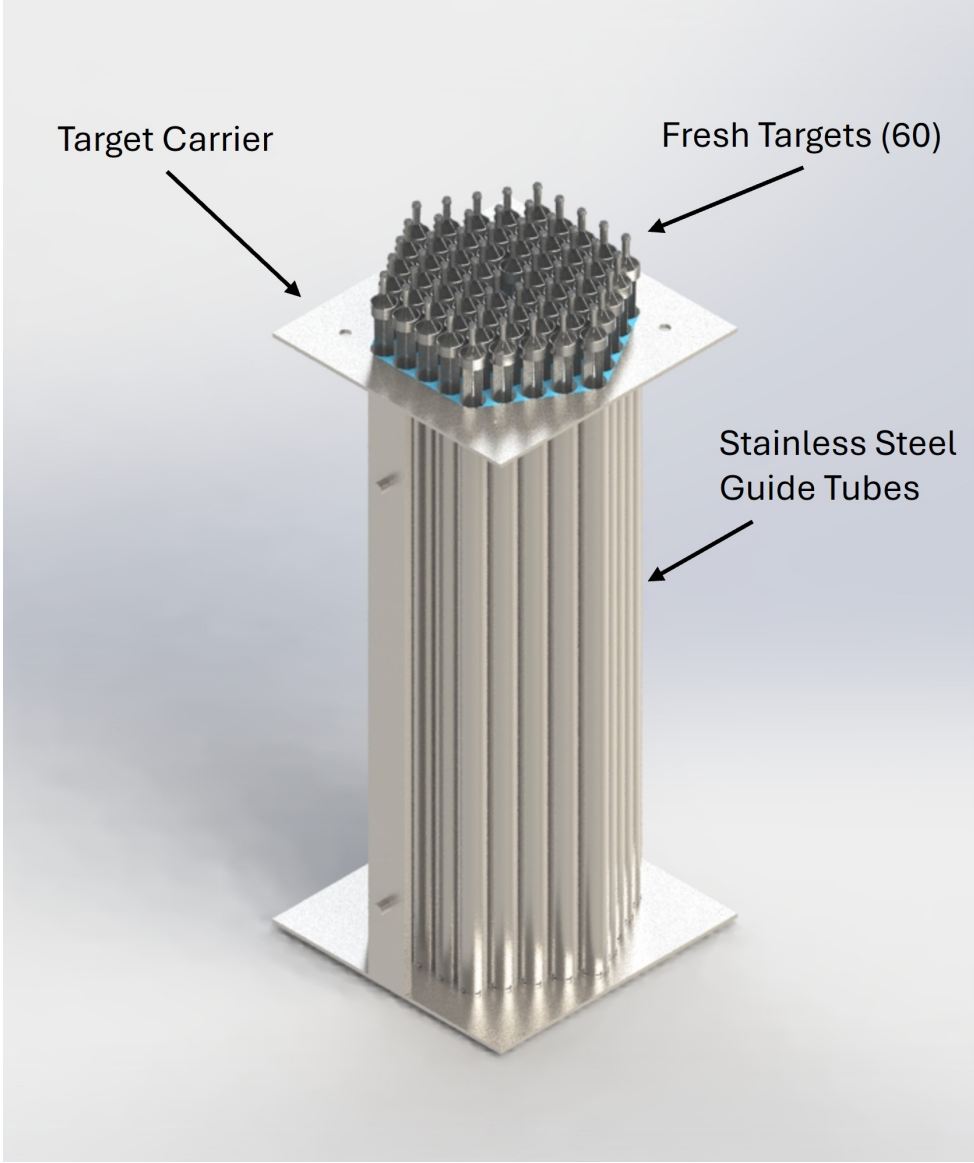

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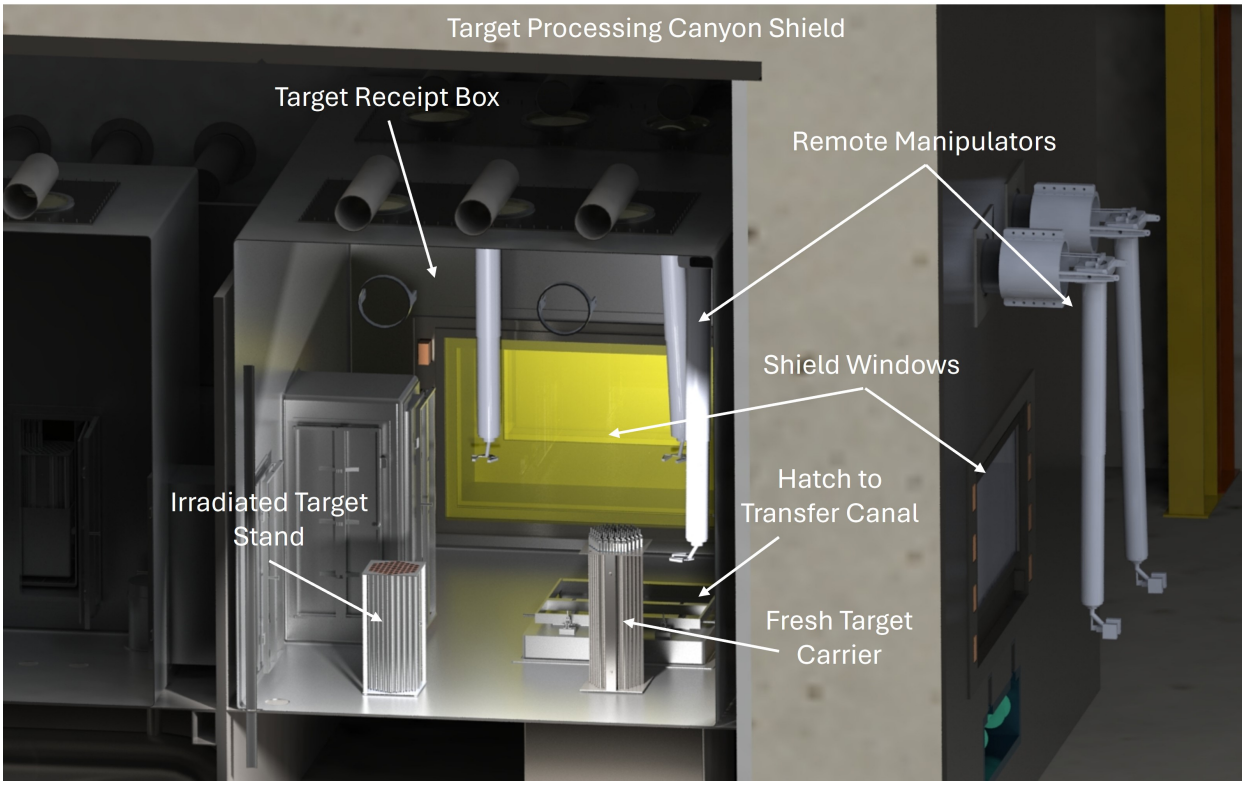
Figure 9b.2-2
Target Receipt Box with Fresh Target Carrier



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Chapter 10
Experimental Facilities and Utilization

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CHAPTER 10
EXPERIMENTAL FACILITIES AND UTILIZATION

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Number	Title

None.

List of Figures

Number	Title

None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
None.	

10 Experimental Facilities and Utilization

10.1 SUMMARY DESCRIPTION

The Eden Medical Isotope Facility does not contain experimental facilities as described in NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content, and the Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content, for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors.

As described in Chapter 4a, the reactor core maintains irradiation locations for the purpose of producing activation radioisotopes such as lutetium-177 as byproduct material. Processing and packaging of these products would be performed in the activation isotope processing area of the Hot Cell Facility as described in Chapter 4b. Details will be provided in the Operating License Application.

10.2 REFERENCES

None.

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Chapter 11
Radiation Protection Program and Waste Management

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CHAPTER 11

RADIATION PROTECTION PROGRAM AND WASTE MANAGEMENT

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11.1-1	Functional Distribution of Radiation Sources and Waste Within the EMIF

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
Ar-41	argon-41
ASME	American Society of Mechanical Engineers
ASSE	American Society of Safety Engineers
Ci	curie
CFR	Code of Federal Regulations
DC	design criterion(a)
DF	decontamination factor
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
ft.	feet
ft^3	cubic feet
gal.	gallon(s)
H-3	hydrogen-3 (tritium)
H/OH	hydrogen/hydroxide
HCF	Hot Cell Facility
HEGA	high-efficiency gas adsorber (filter)
HEPA	high-efficiency particulate air (filter)
HVAC	heating, ventilation, and air-conditioning
I-131	iodine-131

Acronym/Abbreviation	Definition
Kr-88	krypton-88
L	liter
LECS	liquid effluent control system
LEU	low-enriched uranium
LLW	low-level (radioactive) waste
m	meter(s)
mi.	mile(s)
Mo-99	molybdenum-99
mrem	millirem
N-16	nitrogen-16
NIOSH	National Institute for Occupational Safety and Health
NM	New Mexico
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
QC	quality control
REMP	Radiological Environmental Monitoring Program
RF	Reactor Facility
RPP	Radiation Protection Program
SCB	steel confinement box
SSC	structure(s), system(s), and component(s)
TiO_2	titanium dioxide
URENCO	Urenco USA
U.S.	United States
Xe-133	xenon-133

Acronym/Abbreviation	Definition
Xe-135	xenon-135

11 RADIATION PROTECTION PROGRAM AND WASTE MANAGEMENT

11.1 RADIATION PROTECTION

The Radiation Protection Program (RPP) described in this chapter identifies the sources of radiation and describes the program elements for radiation protection at the Eden Isotope Production Complex (EIPC). The program descriptions are at an appropriately high level and identify use of existing approved United States (U.S.) Nuclear Regulatory Commission (NRC) regulatory guides for demonstrating conformance to Title 10 of the Code of Federal Regulations (10 CFR) Part 20. Identifying the expected radiation sources and the commitments to existing approved guidance provides reasonable assurance, consistent with 10 CFR 50.34(b)(3) and 10 CFR 50.40(a), that the regulations in 10 CFR Part 20 will be met, and that the health and safety of the public will not be endangered. A more detailed description of these program elements will be provided in the Operating License Application.

11.1.1 RADIATION SOURCES

This subsection identifies various radiation sources monitored and controlled as part of the RPP and Radioactive Waste Management Program.

The distribution of the radiation sources and the waste within the Eden Medical Isotope Facility (EMIF) is illustrated in Figure 11.1-1. The liquid effluent control system (LECS) collects drain water from decontamination stations, floor drains and reactor pool water overflow. The LECS provides holdup of water for monitoring, cleanup as needed, and ultimate release to the evaporation pond.

The radiation sources associated with the EMIF operations primarily include:

- Reactor and reactor hardware.
- Reactor neutron source and calibration sources.
- Fission chambers and dosimetry foils.
- Irradiated targets during transfer.
- Low-enriched uranium (LEU).
- Targets and target materials in process.
- Process waste.
- Radioactive nonfuel hardware.
- Medical isotope products.
- Primary coolant or LECS (if generated) demineralizer resins.
- Ventilation system filters.

With the exception of the reactor start-up source and instrumentation calibration sources and fission chambers, all radiation sources in the EMIF emanate from LEU irradiated in the reactor or from the neutron activation of materials irradiated near the reactor. Likewise, most radioactive waste generated in or present in the EMIF emanates from LEU irradiated in the reactor or from the neutron activation of materials irradiated near the reactor. Wastes are also generated from contaminated equipment and personal protective equipment (PPE).

LEU in the unirradiated target form or in the recovered form is not a significant radiation source. LEU in these forms is packaged and stored appropriately to avoid inadvertent criticality. Inadvertent criticality is further discussed in Chapters 6b and 13b.

All irradiated LEU remains underwater in the reactor pool or the transfer canal until it is moved underwater to the Hot Cell Facility (HCF). The sealed start-up neutron source remains submerged in the reactor pool.

Activated reactor hardware and components that have reached end of service life are either transferred underwater to the HCF or retrieved manually from the reactor pool and packaged for disposal.

Gaseous radionuclides such as argon-41 (Ar-41), tritium (H-3), and nitrogen-16 (N-16) escaping from the pool water are removed from the Reactor Facility (RF) high bay by the RF high bay ventilation system described in Chapter 9a. The RF is maintained at a negative pressure with respect to the outdoor atmosphere.

Within the HCF, all processing and handling of the irradiated targets are performed in steel confinement boxes (SCBs) located in the target processing canyon. All areas of the HCF are ventilated through either the HCF exhaust stack or the HCF Zone 1a exhaust stack as described in Chapter 6b and 9b. The effluent is filtered as described in Chapters 6b and 9b. The HCF is maintained at a negative pressure with respect to the outdoor atmosphere. The SCBs are maintained at a negative pressure with respect to the target processing canyon, which, in turn, is maintained at a negative pressure with respect to the HCF target processing high bay.

LEU, molybedenum-99 (Mo-99) iodine-131 (I-131), xenon-133 (Xe-133), and other marketable fission products are packaged in shielded and sealed containers.

The process waste is solidified in 55-gallon (gal.) (208-liter [L]) drums and transferred to the waste storage canyon. Product samples are removed from the target processing canyon for quality control (QC) inspection in the HCF QC area.

Instrumentation calibration sources are in the HCF QC area.

Additional details about radiation sources, including activity, composition, and radiation fields, will be provided in the Operating License Application.

11.1.2 RADIATION PROTECTION PROGRAM

An RPP as required by 10 CFR 20.1101 is designed to meet the requirements of 10 CFR Part 19 and 10 CFR Part 20 and developed, documented, and implemented commensurate with the scope and extent of licensed activities for a commercial research utilization and production facility.

As described in this chapter, elements of the RPP include:

- As Low As Reasonably Achievable (ALARA) Program.
- Radiation Monitoring and Surveying.
- Radiation Exposure Control and Dosimetry.

- Contamination Control.
- Respiratory Protection Program.

The RPP is designed and implemented consistent with the following guidance documents:

- American National Standards Institute (ANSI)/American Nuclear Society (ANS) ANSI/ANS-15.11-2016, Radiation Protection at Research Reactors (R2021) (ANSI/ANS, 2021).
- Regulatory Guide 8.2, Administrative Practices in Radiation Surveys and Monitoring, Revision 1.
- Regulatory Guide 8.4, Personnel Monitoring Device – Direct-Reading Pocket Dosimeters, Revision 1.
- Regulatory Guide 8.7, Instructions for Recording and Reporting Occupational Radiation Exposure Data, Revision 4.
- Regulatory Guide 8.9, Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program, Revision 1.
- Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, Revision 3.
- Regulatory Guide 8.29, Instruction Concerning Risks from Occupational Radiation Exposure, Revision 1.
- Regulatory Guide 8.25, Air Sampling in the Workplace, Revision 1.
- Regulatory Guide 8.34, Monitoring Criteria and Methods to Calculate Occupational Radiation Doses, Draft Revision 1.
- Regulatory Guide 4.21, Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning, Revision 0.
- ANSI/American Society of Safety Engineers (ASSE) Z-88.2-2015, American National Standard for Respiratory Protection (ANSI/ASSE, 2015).
- Occupational Safety and Health Administration (OSHA) 29 CFR 1910.134, Respiratory Protection.

Periodic reviews of the RPP content and implementation are performed in accordance with 10 CFR 20.1101(c). Procedures and engineering controls are employed to achieve occupational doses and doses to members of the public that are ALARA, as required by 10 CFR 20.1101(b).

The operational organizational structure of the EIPC is described in Section 12.1. The training portion of the RPP is designed and implemented in accordance with the requirements of 10 CFR 19.12, and recordkeeping is performed in accordance with 10 CFR Part 20, Subpart L.

Additional details will be provided in the Operating License Application.

11.1.3 AS LOW AS REASONABLY ACHIEVABLE PROGRAM

As required by 10 CFR 20.1101, a program to ensure that occupational doses and doses to members of the public are maintained ALARA will be implemented for the EIPC, following the guidance of ANSI/ANS-15.11-2016 (ANSI/ANS, 2021) and Regulatory Guide 8.10, Operating

Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable, Revision 2.

Radiation exposures to workers and members of the public will be maintained below the limits of 10 CFR 20.1201 and 10 CFR 20.1301, as well as below the airborne effluent dose constraint in 10 CFR 20.1101.

Eden Radioisotopes, LLC (Eden) management is committed to the ALARA philosophy for radiological operations. Eden's policy is to conduct radiological operations in a manner that ensures the health and safety of its employees, contractors, and the public. In achieving this objective, Eden ensures that radiation exposures to workers and to the public, and releases of radioactivity to the environment, are maintained within regulatory limits. Deliberate actions are taken to further reduce exposures and releases in accordance with a process focused on keeping exposures or releases ALARA. Eden is fully committed to implementing an ALARA Program that consistently reflects this policy.

Additional details about the ALARA Program for the EIPC will be provided in the Operating License Application, as required by 10 CFR 50.34(b)(3).

11.1.4 RADIATION MONITORING AND SURVEYING

Radiation levels within the EIPC are monitored to ensure they are maintained within safe bounds for both workers and the public, and to ensure continued compliance with regulatory and technical specifications requirements. Radiation surveys focus primarily on the EMIF where instances of occupational radiation dose limits could potentially be exceeded. Measurements of airborne radioactive material and/or bioassays are used to determine that internal occupational exposures to radiation do not exceed the dose limits specified in 10 CFR Part 20, Subpart C, Occupational Dose Limits.

10 CFR Part 20, Subpart F describes the requirements for radiation monitoring and surveying. The purpose of radiation monitoring and surveying is to determine radiation levels, concentrations of radioactive materials, and potential radiological hazards that could be present in the facility, and to detect other radiological hazards and releases of radioactive materials from facility operations and equipment. Surveys and monitoring focus on sections of the EIPC where external exposure or internal uptake of radionuclides can cause occupational doses exceeding limits allowed in 10 CFR Part 20. Monitoring activities are performed with instruments of an appropriate range of response and sensitivity to the types of radiation relevant to the monitored area.

Written procedures are established to ensure compliance with the requirements of 10 CFR Part 20, Subpart F, Surveys and Monitoring. The Radiological Environmental Monitoring Program (REMP) is developed taking into consideration the applicable guidance, as listed above.

A detailed description of the REMP, encompassing the equipment, methods, and procedures, will be provided in the Operating License Application.

11.1.5 RADIATION EXPOSURE CONTROL AND DOSIMETRY

The EMIF is designed to prevent uncontrolled radionuclide releases to work areas or to the environment during normal operations. This is accomplished through the process design and shielding discussed in Chapters 4a and 4b and the facility heating, ventilating, and

air-conditioning (HVAC) and exhaust systems design discussed in Chapter 6b and Chapters 9a and 9b.

11.1.5.1 Process Design for ALARA

Examples of process design considerations that are implemented to reduce personnel radiation exposures include the following:

- Designing all facility structures, systems, and components (SSCs) to ensure that the processing of irradiated targets is performed at a negative pressure level with respect to occupied areas and the atmosphere (see Chapters 4b and 6b).
- Designing all facility SSCs to ensure that the requirement for direct contact of personnel with radiological materials is minimized (see Chapters 4a and 4b).
- Designing to ensure equipment and components include reliability, availability, maintainability, inspectability, constructability, and other design features to reduce or eliminate the need for repair or preventive maintenance.
- Providing design redundancy (multiple process streams) to ensure that if a single component fails, operations can safely continue.
- Designing equipment and piping to minimize accumulation of radioactive materials.
- Providing for draining, flushing, or, if necessary, remote cleaning or decontamination of equipment containing radioactive materials and environmentally safe discharge of resulting liquid effluents.
- Designing air flow at exhausted enclosures and close-capture points, when in use, to preclude escape of airborne radioactive gases and particles and to minimize the potential for intake by workers. Air flow rates are checked periodically when in use and after modification of any hood, exhausted enclosure, close-capture point equipment, or ventilation system serving these barriers.

11.1.5.2 Facility Design for ALARA

Examples of operating considerations that are implemented to reduce personnel radiation exposures include the following:

- Incorporating ease of maintenance of repair, including ease of disassembly and modularization of components for replacement or removal to a lower radiation area for repair or disposal.
- Providing the capability to remotely or mechanically operate, repair, service, monitor, or inspect equipment.
- Laying out the EMIF so that access to a given area does not require passing through a higher-radiation zone area.
- Providing the ability to operate equipment from accessible areas both during normal and off-normal operating conditions.
- Providing areas outside of high-radiation areas into which equipment can be moved to for service.
- Incorporating ease of decontamination of potentially contaminated areas.

- Providing control systems so that process controls (e.g., essential instrumentation and controls) are from the lowest-radiation zone practicable.
- Controlling HVAC system contamination by maintaining ventilation air flow patterns from areas of lower radioactivity to areas of higher radioactivity.
- Requiring self-monitoring when exiting restricted areas; if contamination is detected, facility personnel are required to notify radiation protection staff.
- Training EIPC personnel in emergency evacuation procedures in accordance with the Emergency Plan (see Chapter 12).

Effluents are monitored for radioactivity during normal operations and postulated events, and SSCs are designed to limit uncontrolled liquid or gaseous effluent releases to work areas or to the environment, consistent with the goal of maintaining radiation exposures ALARA. Releases during postulated events are discussed in Chapters 13a and 13b.

11.1.5.3 Anticipated Annual Exposures from Routine Radioisotope Releases from the Reactor Facility

Radionuclides are produced in the reactor pool water due to neutron activation. The main isotopes produced in the water are N-16, Ar-41, and H-3. Of these three isotopes, only Ar-41 and H-3 have half-lives long enough to be a concern as an airborne release from the pool to a member of the public via the RF high bay and exhaust stack. Table 11.1-1 lists the estimated annual Ar-41 and H-3 releases from the RF high bay exhaust stack, with no filtering, with the reactor operating at 1.8 megawatts-thermal continuously. Also listed in the table are the estimated dose values for different potential receptors calculated using the COMPLY code (Version 1.7), assuming the receptor was at the location 24 hours per day throughout the year. The wind data used was for Hobbs, New Mexico (NM). A 15-meter (m)-high (49-foot (ft.)-high) stack was assumed with no exit velocity and no building wake effects. A screening level of 4 was used in the calculation.

The dose locations represent the nearest residence in Eunice, NM, 1.7 miles (mi.) (2740 m) west-northwest from the EMIF, the nearest work location for the Urenco USA (URENCO) facility, 0.85 mi. (1370 m) north-northeast from the EMIF (conservative distance used in the analysis), and the site boundary 0.31 mi. (500 m) north of the EMIF.

11.1.5.4 Anticipated Annual Exposures from Routine Radioisotope Releases from the Hot Cell Facility

Some airborne radionuclides are routinely released from the HCF during the irradiated target processing activities in the target processing canyon. Noble gas fission products (krypton and xenon) and halogen fission products (iodine) are released during the LEU foil dissolution process. Because the dissolution process is performed in a sealed dissolver unit, the routine airborne releases are those associated with making and breaking connections on the unit and during the transfer of fluids from the unit through the titania column. During the dissolution process, the LEU foil is completely dissolved in a nitric acid solution within the dissolver unit. During this process, the noble gases and halogens are released from the solution into the cover gas. After the LEU foil is completely dissolved, the unit is evacuated to the fission gas delay system. Gases released into a dissolver box are exhausted through the HCF Zone 1a exhaust stack after passing through a high-efficiency gas adsorber (HEGA) and high-efficiency particulate air (HEPA) filter system.

For this analysis, it is assumed that no filtering (decontamination factor [DF] equal to 1.0) occurs for the noble gases released and discharged through the exhaust stack. For the halogens, a DF of 10,000 is assumed for the inline HEGA and HEPA filters prior to discharge through the exhaust stack. A release fraction of 1 percent is assumed for the noble gases and halogens for the dissolution process.

Table 11.1-2 shows the estimated annual noble gas and halogen releases from the HCF exhaust stack or the HCF Zone 1a exhaust stack, assuming 2000 targets are processed per year with each target irradiated at 30 kilowatts-thermal for 25 days. The fission product inventory assumes a 4-hour decay of the targets prior to processing. Only the isotopes contributing significantly to the receptor dose are shown. Also shown in the table are the estimated dose values for different potential receptors calculated using the COMPLY code (Version 1.7), assuming the receptor was at the location 24 hours per day throughout the year. The wind data used was for Hobbs, NM. A 15-m-high (49-ft-high) stack was assumed with no exit velocity and no building wake effects. A screening level of 4 was used in the calculation.

The dose locations represent the nearest residence in Eunice, NM, 1.7 mi. (2740 m) west-northwest from the EMIF; the nearest work location for the URENCO facility, 0.85 mi. (1370 m) (conservative distance used in the analysis) north-northeast from the EMIF, and the site boundary 0.31 mi. (500 m) north of the EMIF. The calculated dose at all locations for members of the public is significantly below the 100-millirem (mrem) regulatory requirement given in 10 CFR 20.1301. The calculated dose for the nearest resident and for the URENCO site is well below the 10-mrem ALARA dose constraint for members of the public given in 10 CFR 20.1101. The calculated dose at the site boundary is above the dose constraint. However, this dose is based on very conservative assumptions. For example, it is assumed that a member of the public is at the site boundary continuously. A more realistic, but still conservative, assumption that the person is at the site boundary half time (12 hours per day, 365 days per year) reduces the calculated dose to less than 10 mrem. During operation, Eden will have in place a REMP and will monitor effluents released from the EMIF to confirm that actual doses at the site boundary are within the regulatory dose constraint of 10 mrem.

11.1.5.5 Control of Entry

As stated in Subsection 11.1.2, procedures and engineering controls are employed, to the extent practical, to achieve occupational doses and doses to members of the public that are ALARA, as required by 10 CFR 20.1101(b). ALARA action levels initiate investigations should doses in any area of the facility exceed ALARA Program goals.

Within the EMIF, radiological areas are established to protect against undue risks from exposure to radiation and radioactive materials, and access to high and very high radiation areas is controlled. The radiological areas are locked to limit access and alarms and signals are present to alert workers to potential unauthorized entry into radiological areas. Precautionary procedures governing access controls, signage, and labeling are developed as required by 10 CFR Part 20, Subparts G and J, which includes access requirements for both 10 CFR 20.1601 and 20.1602. Shielding and remote handling equipment is provided for worker protection from high-radiation areas.

11.1.5.5.1 Controlled Area

The NRC defines a controlled area as one that is outside of a restricted area but inside the site boundary, in which the licensee can limit access for any reason. For the EIPC, as described in

Section 2.1, the site boundary and the controlled area boundary are coincident. Due to the presence of administrative and physical barriers, members of the public do not have direct access to this controlled area and must be processed by security for authorized entry. The site boundary fence has physical controls in place to limit public access to the controlled area. Training for access is provided commensurate with the radiological hazards.

Visitors to the facility include those who are temporary, transient occupants of the controlled area, such as service personnel, delivery workers, and tourist groups. Area monitoring demonstrates compliance with public exposure limits for such transient visitors.

11.1.5.5.2 Radiological Zones

Radiological zones with varied definitions and span of control are designated for the EIPC and for areas surrounding the EIPC site. The purposes of these zones are to (1) control the spread of contamination, (2) control personnel access to avoid unnecessary exposure to radiation, and (3) control personnel access to radioactive sources present in the facility. Public access to radiological zones is restricted as described below and as directed by Eden management. Areas where personnel spend substantial amounts of time are designed to minimize the exposure received when routine tasks are performed, in accordance with the ALARA principle.

The definitions summarized below are provided to describe how the RPP is implemented to protect workers and the general public on the site. Additional information will be provided in the Operating License Application.

11.1.5.5.2.1 Restricted Areas

The NRC defines a restricted area as one that the licensee limits access to for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Access to and egress from a restricted area at the EIPC is through a radiation protection control point. Monitoring equipment is located at these control points. The EMIF is in a restricted area. Personnel who have not been trained in radiation protection procedures are not allowed to access this area without escort by trained personnel. All personnel are required to self-monitor prior to exiting restricted areas.

Additional temporary or permanent areas may be defined within the restricted area. These areas are defined in 10 CFR 20.1003, Definitions. The areas are posted in accordance with the requirements of 10 CFR Part 20 to inform workers of the potential hazards in the area and to help prevent the spread of contamination.

11.1.5.5.2.2 Unrestricted Areas

The NRC defines an unrestricted area as one that the licensee neither limits nor controls. The area adjacent to the EIPC is an unrestricted area. This area can be accessed by members of the public or by facility personnel. The unrestricted area is governed by the limits in 10 CFR 20.1301.

11.1.5.6 Protective Equipment and Materials

Personnel working within the radiological areas are required to wear appropriate PPE and form of protective clothing. The form of protective clothing/equipment used is based on consideration of the contamination level in the work area, anticipated work activity, worker health factors, and

nonradiological hazards present. Protective clothing/equipment is made readily available, as necessary.

Areas requiring protective clothing/equipment are posted at each of the associated entry points. Radiation protection management and technical staff are responsible for determining the need for protective clothing/equipment in each work area and documenting these requirements in the Radiation Work Permit.

Airborne radioactivity concentrations are minimized to the extent practical using engineered controls (e.g., confinement, ventilation) and are not normally present in the work areas. When establishing radiological controls for work involving potential airborne radioactivity, the first consideration is to use techniques that help prevent or reduce the potential for airborne radioactivity and maintain loose surface contamination in work areas within ALARA levels. Respiratory protection equipment requirements is as specified in the Radiation Work Permit.

All personnel whose duties require entry into radiological areas must wear individual external dosimetry devices (e.g., passive dosimeters, such as thermoluminescent detectors that are sensitive to beta, gamma, and neutron radiation). External dosimetry devices are evaluated at least quarterly to ascertain external exposures.

Additional details about the dosimetry and radiation exposure control for the facility, including the locations of radiological areas, access controls, shielding, remote handling equipment, and expected annual radiation exposures, will be provided in the Operating License Application, as required by 10 CFR 50.34(b)(3).

11.1.6 CONTAMINATION CONTROL

In accordance with the requirements of 10 CFR 20.1406, SSCs with the potential to contain/handle radiological materials incorporate design considerations to limit leakage and control the spread of contamination and to facilitate eventual decommissioning. Such design features consider the guidance in Regulatory Guide 4.21 and include the following considerations and administrative controls:

- Minimizing the potential for leaks and spills to prevent the spread of contamination.
- Measures to detect leakage to minimize the potential to spread contamination.
- Measures to reduce the need to decontaminate SSCs.
- Periodic reviews of operations, procedures, and practices.

In addition, the applicable guidance documents, as listed above, are considered.

A detailed description of the design features and procedures for the control of radioactive contamination for the EIPC facility, including consideration of Regulatory Guide 4.20, Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors, Revision 1, will be provided in the Operating License Application, consistent with 10 CFR 50.34(b)(3).

11.1.7 ENVIRONMENTAL MONITORING

Pursuant to 10 CFR 20.1302, environmental monitoring is required to demonstrate compliance with the dose limits for individual members of the public. To meet these requirements, an

operational REMP will be established. Baseline condition evaluations are made by taking soil samples and gamma surveys of the area around the site prior to operational activities. The operational REMP will consider the guidance in Regulatory Guide 4.1, Radiological Environmental Monitoring for Nuclear Power Plants, Revision 2, Sections C.2 and C.3, for establishing and conducting the environmental monitoring program used during plant operations. Regulatory Guide 4.1 refers to NUREG-1301, Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, for additional guidance on the effluent and environmental monitoring. Both Regulatory Guide 4.1 and NUREG-1301 are written for nuclear power plants rather than medical radioisotope facilities. However, there are similarities in airborne releases of radioactivity such that the guidance in Regulatory Guide 4.1 and NUREG-1301 is considered generally relevant (with consideration of the Eden technology) for developing the operational REMP for the EIPC.

The REMP will be implemented coincident with the start of plant operational activities. As such, the description of the environmental monitoring program, including consideration of Regulatory Guide 4.1 and NUREG-1301, will be provided with the application for an Operating License consistent with 10 CFR 50.34(b)(3).

Table 11.1-1
Estimated Annual Radioactive Airborne Releases and Doses from the Reactor Facility

Radionuclide	Annual Release (Ci)	Dose (mrem) 1.7 mi. West-Northwest	Dose (mrem) 0.85 mi. North-Northeast	Dose (mrem) 0.31 mi. North
Ar-41	14.7	2.50E-04	1.35E-03	1.25E-02
H-3	0.0175	5.95E-08	3.15E-07	2.80E-06
Total		**2.50E-04**	**1.35E-03**	**1.25E-02**

Abbreviations: Ci = curie(s) | mrem = millirem | mi. = mile(s) | Ar-41 = argon-41 | H-3 = tritium

Table 11.1-2
Estimated Annual Radioactive Airborne Releases and Doses from the Hot Cell Facility

Radionuclide	Annual Release (Ci)	Dose (mrem) 1.7 mi. West-Northwest	Dose (mrem) 0.85 mi. North-Northeast	Dose (mrem) 0.31 mi. North
Kr-88	6.77E+03	2.64E-01	1.35E+00	1.22E+01
Xe-133	3.07E+04	4.30E-02	7.68E-02	7.06E-01
Xe-135	1.24E+04	4.21E-02	2.23E-01	1.98E+00
I-131	1.22E+00	2.33E-02	3.18E-02	1.22E-01
Total		**3.72E-01**	**1.68E+00**	**1.50E+01**

Abbreviations: Ci = curie(s) | mrem = millirem | mi. = mile(s) | Kr-88 = krypton-88 | Xe-133 = xenon-133 | Xe-135 = xenon-135 | I-131 = iodine-131

11.2 RADIOACTIVE WASTE MANAGEMENT

Radioactive waste generation occurs at the EMIF (see Figure 11.1-1) during the production of Mo-99, where LEU target irradiation is performed in the RF and subsequent target processing is performed in the HCF. The waste management systems described below provide mechanisms for the collection and disposition of the waste in accordance with applicable state, NRC, and other federal environmental regulations. These systems are designed to limit discharges of radioactive materials in accordance with 10 CFR Part 20. The methods employed for the controlled release of radioactive material are dependent primarily on the state of the material (i.e., solid or liquid). The EMIF does not require a gaseous radioactive waste system. Soft radioactive waste (e.g., PPE) is created in all EMIF radiation areas. This section describes the management program, systems, controls, disposal paths, and packaging for each anticipated radioactive waste stream generated by the EMIF.

11.2.1 RADIOACTIVE WASTE MANAGEMENT PROGRAM

A detailed description of the Radioactive Waste Management Program for the EIPC will be provided in the Operating License Application. In accordance with 10 CFR 50.34(b)(6), the description will address organization and staffing levels, authorities and responsibilities, position qualifications, personnel training requirements, and document control and recordkeeping procedures. The preliminary EIPC organizational structure is described in Section 12.1.

The Radioactive Waste Management Program is periodically reviewed to identify opportunities to improve its capabilities to maintain these waste volumes and activities ALARA. This review includes periodic assessment of the waste streams to find means to minimize waste generation and identify methods to reduce waste volumes. Additional details will be provided in the Operating License Application.

Eden plans to enter into a lease take-back agreement with the U.S. Department of Energy to provide for the disposal of any waste that does not have a commercial disposal pathway.

11.2.2 RADIOACTIVE WASTE HANDLING SYSTEMS AND CONTROLS

11.2.2.1 Description

The radioactive waste handling systems described in this section provide for collecting, packaging, storing, and dispositioning low-level radioactive wastes (LLW) in solid and liquid forms. Components removed or replaced during maintenance are radiologically and chemically decontaminated (where practical) and appropriately dispositioned for refurbishment or disposal. Cleaning materials used to remove component contamination are controlled and included in the requisite waste disposal path. Contaminated liquids from unanticipated events (overflow/spills) are controlled by engineered features (e.g., berms and drains) or by actions performed by operations personnel.

The radioactive waste handling systems are designed to meet the requirements of 10 CFR 20.1406 as related to the minimization of contamination and eventual decommissioning of the facility.

A summary description of the EMIF radioactive waste handling systems is provided below.

11.2.2.1.1 Liquid Radioactive Waste Systems

The design basis for the LECS is as follows:

- The LECS provides water collection tanks that can be sampled for radionuclide content prior to release of the water to the evaporation pond.
- The LECS provides for the removal of radionuclides from the water collection tanks using a portable cleanup system if the water sampling results indicate radionuclide content is above the release limits.

An underground pipeline system is used to transport the LECS wastewater from the EMIF decontamination stations, laboratory spaces, and floor drains where radioactive and/or hazardous chemicals may be present. These pipelines are equipped with leak-detection devices to immediately identify spills. Water potentially containing radioactive impurities is collected by a separate drain system and delivered to the LECS storage tanks, where it is monitored and treated to remove contaminants and ultimately discharged to the evaporation pond. The LECS contains three 37,800 L (10,000 gal.) holding tanks that are in a dry concrete berm. Drains and sump pumps are used in the RF to control any leakage or overflow of water on the primary side of the system. Any water collected from the pool (including overflow) or the primary side of the coolant system is transferred to the LECS storage tanks. Other potentially contaminated water sources are also transferred to the LECS from other parts of the EMIF, including the HCF. The water transferred to the LECS storage tanks is then sampled for radionuclides. If required, this contaminated water is cycled through a portable cleanup system. Once the activity in the water is verified below 10 CFR Part 20 Appendix B requirements, the water is released to the evaporation pond.

There are no airborne radiation sources in or from the LECS. The activity levels of the reactor pool water and the LECS water are very low and do not constitute a significant radiation hazard. The only solid radiation source in the LECS is the portable demineralizer beds. Their anticipated activity is estimated to be in the millicurie range.

There are no automatic systems or features in the LECS.

The RF sump provides facility support equipment functions that are monitored and controlled by operators using the Balance of Plant display and controls systems (see Section 7a.6.3).

In summary, the LECS design basis functionality includes the following:

- Providing a location where any liquid water from the RF and HCF is collected, including water from the pool, reactor primary coolant system, or the reactor secondary coolant.
- Providing water collection tanks that can be sampled for radionuclide content prior to the release of the water to the evaporation pond.
- Removing radionuclides from LECS storage tanks using a portable cleanup system if the water sampling results indicate that radionuclide content is above release limits.

The following design criteria (DC) apply to the LECS:

- DC 18, Control of Releases of Radioactive Materials to the Environment: The LECS provides means to control the release of radioactive materials in liquid effluents

produced during normal operation, anticipated operational occurrences, and accident conditions. Sufficient holdup capacity is provided for retention of liquid effluents containing radioactive materials.

- DC 19, Radioactive Material Control: The LECS is designed to ensure adequate safety during normal operation, anticipated operational occurrences, and accident conditions. Measures are provided to (1) detect conditions that may result in excessive radiation levels and (2) initiate appropriate safety actions. The LECS design includes the capability to perform appropriate periodic inspection and testing.
- DC 21, Monitoring Radioactive Releases: The LECS is designed to include monitoring the effluent discharge paths and plant environs for radioactivity that may be released during normal operations, anticipated operational occurrences, and accident conditions.

The LECS is designed to the following relevant codes and standards:

- American Society of Mechanical Engineers (ASME) B31.1-2024, Power Piping, (ASME, 2024).
- ASME B16.34-2025, Valves — Flanged, Threaded, and Welding End, (ASME, 2025).

11.2.2.1.2 Solid Radioactive Waste System

Solid radioactive waste systems provide for collecting, processing, packaging, and storing wet and dry solid radioactive waste produced from normal facility operations and maintenance. LLW is collected on-site and shipped to a licensed radioactive waste disposal facility.

All radioactive and contaminated wastes are disposed in solid form and sent to disposal in 55-gal. (208-L) drums, with the exception of equipment that does not readily fit in drums, including HEGA/HEPA filters. Large equipment and HEPA filters are sent to disposal in boxes. Minimizing waste volume is accomplished through compaction of glassware and other compressible solids. The solidified process waste is in such a form as to minimize the number of waste drums needed.

The following DC apply to the design of the solid radioactive waste system:

- DC 18, Control of Releases of Radioactive Materials to the Environment: The solid radioactive waste system is designed to handle solid wastes produced during normal operation, anticipated operational occurrences, and accident conditions.
- DC 19, Radioactive Material Control: The solid radioactive waste systems are designed to assure adequate safety of the waste during normal operation, anticipated operational occurrences, and accident conditions. System design includes the capability to perform appropriate periodic inspection and testing.

These design criteria also apply to the waste systems described in Subsections 11.2.2.1.3, 11.2.2.1.4, and 11.2.2.1.5.

11.2.2.1.3 Reactor Primary Coolant Cleanup System Waste

The reactor primary coolant cleanup system employs a hydrogen (H)/hydroxide (OH) mixed resin bed demineralizer to maintain acceptable water quality for the reactor pool, transfer canal,

and the reactor primary coolant cleanup system. The reactor primary coolant cleanup system demineralizer resin contains some radionuclide loading and must be disposed of as LLW.

11.2.2.1.4 Hot Cell Facility Waste

HCF target processing canyon waste is neutralized, solidified, packaged in waste drums, and temporarily stored in the waste storage canyon. This includes process hardware and glassware that is utilized within the HCF target processing canyon, such as target cladding and end fittings, dissolver units, glassware, and titanium dioxide (TiO_2) columns. After an appropriate decay time, the waste drums are sent in approved shipping containers to a licensed radioactive waste disposal facility as a Class C or lower LLW.

11.2.2.1.5 Miscellaneous Radioactive Solid Waste

Radioactive and/or contaminated hardware from areas outside the HCF target processing canyon, primary coolant or LECS (if generated) demineralizer resins, and HEGA/HEPA filters are packaged and temporarily stored on-site until such time as they are disposed at a licensed radioactive waste disposal facility as Class A LLW. Some contaminated hardware may be decontaminated and reused. Contaminated PPE and other contaminated disposables are either decontaminated for reuse or packaged and temporarily stored on-site, and later sent to a licensed radioactive waste disposal facility as Class A LLW.

11.2.2.1.6 Gaseous Radioactive Waste System

The EMIF does not require a gaseous radioactive waste system. Any gaseous radioactive effluents generated are discharged through the RF high bay ventilation system and the HCF ventilation systems. Releases to the atmosphere are controlled and monitored such that the total radiation exposure to persons outside the controlled area is ALARA and does not exceed applicable regulations.

11.2.2.2 System Evaluation

Releases of radioactive materials to the environment from the radioactive waste handling systems are controlled such that they remain within the limits of 10 CFR Part 20. The radioactive waste handling systems are not safety-related; as such, they are not credited with performing any safety functions. The radioactive waste handling systems are designed so that postulated failures of SSCs in the system from differential displacements do not preclude a safety-related SSC from performing its safety function.

The radiation monitoring system (Subsection 11.1.4) provides for monitoring of the radioactive waste handling systems. The radioactive waste handling systems are designed to minimize contamination and support eventual decommissioning, consistent with the requirements of 10 CFR Part 20.1406, as described above.

11.2.2.3 Technical Specifications, Testing, and Inspection

Periodic functional tests and inspections of the radioactive waste handling systems are performed during facility operation.

Potential variables, conditions, or other items that are probable subjects of a technical specification are provided in Chapter 14. Final technical specifications will be provided in the Operating License Application.

11.2.3 RELEASE OF RADIOACTIVE WASTE

The type, composition, and estimated annual quantity of all anticipated radioactive waste generated during operations are identified in Table 11.2-1.

Solid and liquid radioactive wastes are assayed prior to disposal or release to ensure that the waste is released appropriately with respect to federal, state, and local regulations.

A detailed description of the radioactive effluents from the facility, including points of effluent release and effluent monitoring equipment, will be provided with the Operating License Application, consistent with 10 CFR 50.34(b)(3).

Table 11.2-1
Type and Estimated Annual Quantities of Radioactive Wastes Generated During Operations

Description	Matrix	Class as Generated	Contents	Volume	55-gal. Drum Equivalent as Shipped
Process waste	Solid	C	Fission product raffinate waste immobilized in grout matrix, along with target cladding, dissolvers, glassware, and TiO_2 columns that are used in the target processing activities.	22,000 gal.	400
Wastewater	Liquid	N/A	Potential wastewater collected in the LECS from reactor coolant system and floor drains in the RF and the HCF.	2335 gal.	N/A
PPE and anti-contamination clothing and materials	Solid	A	Contaminated PPE clothing and materials that require disposal.	3080 gal.	56
Other LLW	Solid	A	Chemwipes, tape, plastic, and other items.	880 gal.	16
Demineralizer resin	Solid	A	Demineralizer resin used for LEU and fission product cleanup of primary coolant and LECS wastewater.	425 L	3
HEPA and HEGA filters	Solid	A	Discarded HEPA and HEGA filters.	80.5 ft^3 HEPAs 3.8 ft^3 HEGAs	N/A

Abbreviations: gal. = gallon(s) | TiO_2 = titanium dioxide | N/A = not applicable | LECS = liquid effluent control system | RF = Reactor Facility | HCF = Hot Cell Facility | PPE = personal protective equipment | LLW = low-level waste | LEU = low-enriched uranium | L = liter(s) | HEPA = high-efficiency particulate air (filter) | HEGA = high-efficiency gas adsorber (filter) | ft^3 = cubic feet

11.3 RESPIRATORY PROTECTION PROGRAM

10 CFR Part 20, Subpart H, defines the required elements of the EMIF respiratory protection and ventilation programs. The use of engineering controls is preferred over the use of respirators to minimize radioactive materials in the air. However, in addition to engineering controls, other measures that can be employed to control personnel exposure to radioactive materials in the air to maintain total effective dose equivalents to ALARA levels include:

- Control of access.
- Limitation of exposure times.
- Use of respiratory protection equipment.
- Other controls.

The Respiratory Protection Program is designed to comply with the requirements of ANSI/ASSE Z-88.2-2015 (ANSI/ASSE, 2015); 10 CFR Part 20, Subpart H; and OSHA 29 CFR 1910.134, Respiratory Protection.

Respirators are issued and managed via appropriate program controls if radiation protection management determines that engineering controls alone are ineffective for lowering the potential total effective dose that may be received in a given area, and/or the physical stress of wearing a respirator does not interfere with worker health and safety from an industrial usage/ergonomics standpoint.

If it is decided to use respiratory protection equipment to limit the intake of radioactive and hazardous materials, National Institute for Occupational Safety and Health (NIOSH)-certified equipment will be used.

Further details will be provided in the Operating License Application.

11.4 REFERENCES

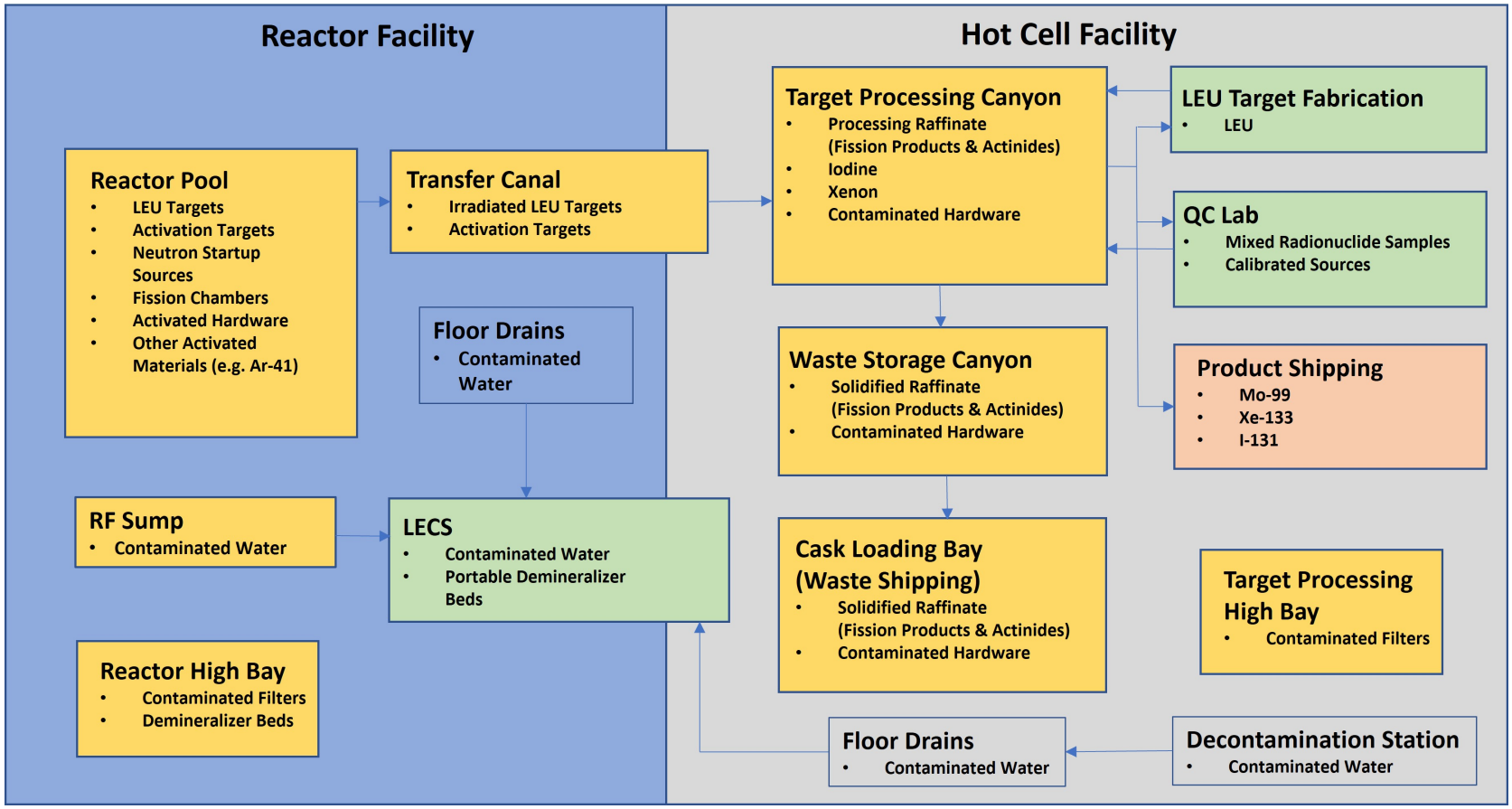
ANSI/ANS, 2021. Radiation Protection at Research Reactors, ANSI/ANS-15.11-2016 (R2021), American National Standards Institute, American Nuclear Society, approved 2016, reaffirmed 2021.

ANSI/ASSE, 2015. American National Standard Practices for Respiratory Protection, ANSI/ASSE Z88.2-2015, American National Standards Institute, American Society of Safety Engineers, 2015.

ASME, 2024. Power Piping, ASME B31.10.2, American Society of Mechanical Engineers, 2024.

ASME, 2025. Valves – Flanged, Threaded, and Welding End, ASME B16.34, American Society of Mechanical Engineers, 2025.

Figure 11.1-1
Functional Distribution of Radiation Sources and Waste Within the EMIF



Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 12
Conduct of Operations

Precision Science.
Human Impact.

CHAPTER 12
CONDUCT OF OPERATIONS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ALARA	As Low As Reasonably Achievable
ANSI/ANS	American National Standards Institute/American Nuclear Society
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
COO	Chief Operating Officer
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
HCF	Hot Cell Facility
MC&A	Material Control and Accounting
NRC	United States Nuclear Regulatory Commission
QAP	Quality Assurance Program
QAPD	Quality Assurance Program Description
RF	Reactor Facility

12 Conduct of Operations

This chapter describes conduct of operations for the Eden Isotope Production Complex (EIPC). It includes administrative aspects of facility operations, emergency planning, security planning, the Quality Assurance Program (QAP), operator training and qualification planning, startup planning, and the Material Control and Accounting (MC&A) Program. The administrative aspects of facility operations are organization, staffing, selection and training of personnel, review and audit activities, organizational aspects of radiation safety, facility procedures, required actions in case of license or technical specification violations or certain events or observations, reporting requirements, and recordkeeping.

12.1 ORGANIZATION

This section describes the EIPC operational structure, functional responsibilities, levels of authority, and interfaces for establishing, executing, and verifying the organizational structure for the EIPC. The organizational structure includes internal and external functions including interface responsibilities for multiple organizations. The organizational aspects of the Radiation Protection Program, the production facility safety program, staffing, and selection and training of personnel are also discussed in this section.

12.1.1 STRUCTURE

The organizational structure for facility operations is provided in Figure 12.1-1.

Eden Radioisotopes, LLC (Eden) management functional levels and assignments of responsibility are as follows:

a. Level 1: Individuals responsible for the facility license.
b. Level 2: Individuals responsible for the facility operation.
c. Level 3: Individuals responsible for day-to-day operation or shift.
d. Level 4: Operating staff.

12.1.2 RESPONSIBILITY

Eden Radioisotopes, LLC is the entity with legal responsibility for holding the Construction Permit and the facility Operating License. All functional positions in the organizational structure have responsibility for safe operation of the EIPC, protection of the health and safety of the public and workers at the facility, and protection of the environment. Responsibilities for the key functional positions in the organizational structure are described in the following subsections, consistent with Figure 12.1-1. The responsibilities of one level may be assumed by designated alternates or by higher levels, conditional upon appropriate qualifications.

12.1.2.1 Chief Executive Officer (Level 1)

The Chief Executive Officer (CEO) is responsible for the overall management and leadership of the company. The CEO reports to the Eden Board of Directors with respect to all matters. The CEO is also responsible for all technical and administrative support activities provided by Eden. The CEO provides direction to the Chief Operating Officer (COO) regarding company business and strategic objectives.

12.1.2.2 Chief Operating Officer (Level 1)

The COO reports to the CEO and is responsible for compliance with the Construction Permit and Operating License and for overall management and leadership of the EIPC.

The COO provides direction to the Site Director and delegates sufficient responsibility and authority to ensure that appropriate controls have been established and to verify that activities have been correctly performed. The COO also authorizes access to necessary work areas and encourages managers and employees to identify and report problems, initiate, recommend, or provide corrective action, and ensure corrective action implementation. The COO establishes and is advised by the Review and Audit Committee.

12.1.2.3 Site Director (Level 2)

The Site Director is responsible for compliance with the facility Operating License and overall management and leadership of EIPC operations. The Site Director provides direction to the Facility Operations Manager and the Technical Support Services Manager regarding plant business and facility strategic performance objectives. The Site Director is also responsible for establishing and managing the required training programs to support the organization and for establishing and maintaining the programs and systems to ensure protection of the company's assets. The Site Director reports directly to the COO. The Site Director is the final certification authority for individuals qualifying for senior licensed operator, licensed operator, or certified operator status.

12.1.2.4 Facility Operations Manager (Level 2)

The Facility Operations Manager is responsible for safe, reliable, and efficient plant operations within the constraints of the Operating License and regulatory requirements. The Facility Operations Manager is also responsible for the protection of personnel from radiation exposure resulting from site operations and materials. The Facility Operations Manager reports directly to the Site Director.

12.1.2.5 Reactor Facility and Hot Cell Facility Operations Managers (Level 2)

The Reactor Facility (RF) and Hot Cell Facility (HCF) Operations Managers report directly to the Facility Operations Manager and are responsible for safe, reliable, and efficient plant operations within the constraints of the Operating License and regulatory requirements. The RF and HCF Operations Managers lead and supervise direct reports. Their responsibilities include interviewing, hiring, training, mentoring, fostering career growth, and performance appraisal.

12.1.2.6 RF and HCF Shift Supervisors (Level 3)

The RF and HCF shift supervisors (Level 3) are senior licensed or certified operators and are responsible for the safe day-to-day operation of the facility. The shift supervisors report directly to their respective Operations Managers.

12.1.2.7 RF Senior Licensed Operators and Licensed Operators, HCF Certified Operators and Field Operators (Level 4)

Senior licensed operators, licensed operators, certified operators, and field operators are responsible for conforming to applicable rules, regulations, and procedures for operation of the

facility. Senior licensed operators, licensed operators and certified operators are responsible for maintaining their qualification status. Field operators are non-licensed operations personnel. Senior licensed operators, licensed operators, certified operators, and field operators report directly to their respective shift supervisors.

12.1.2.8 Technical Support Services Manager (Level 2)

The Technical Support Services Manager is responsible for technical aspects of the facility, including testing, maintenance, engineering, chemistry, emergency planning, security, regulatory affairs, and document management. The Technical Support Services Manager reports directly to the Site Director.

12.1.2.9 Technical Services Supervisors (Level 3) and Technical Services Staff (Level 4)

Individual Technical Services Supervisors report to the Technical Support Services Manager. Technical Services Supervisors (Level 3) and Technical Services Staff (Level 4) are responsible for safely conducting their respective work assignments in strict accordance with established facility procedures.

12.1.2.10 Quality Assurance Manager

The Quality Assurance Manager reports to the Site Director and is responsible for the development and verification of implementation of the Eden QAP. The Quality Assurance Manager is responsible for assuring compliance with regulatory requirements and procedures through assessments and technical reviews, monitoring organizational processes to ensure conformance to commitments and licensing document requirements, and ensuring that suppliers are providing quality services and that parts and materials to the EIPC are meeting requirements defined in the QAP. The Quality Assurance Manager has sufficient independence from other priorities to bring forward issues affecting safety and quality and makes judgements regarding quality in all areas necessary regarding EIPC activities. The Quality Assurance Manager reports to the CEO and COO any quality issues that cannot be resolved at the Site Director level. The Quality Assurance Manager has the authority to terminate unsafe activities.

12.1.2.11 Radiation Protection Manager

The Radiation Protection Manager reports directly to the Site Director and is responsible for establishing and implementing the Radiation Protection Program, including nuclear criticality safety, and the As Low As Reasonably Achievable (ALARA) Program, monitoring worker doses, and calibration of health physics instrumentation. The Radiation Protection Manager has communication lines with the Facility Operations Manager and the RF and HCF Operations Managers. The Radiation Protection Manager has the authority to terminate unsafe activities.

12.1.2.12 Review and Audit Committee

The Review and Audit Committee is responsible for the independent review and audit of the safety aspects of EIPC operations. The Review and Audit Committee reports to and is chaired by the COO or designee and has communication lines with the Site Director and direct reports. The Review and Audit Committee is described in Section 12.2.

12.1.3 STAFFING

Eden will provide sufficient personnel and materials resources to safely conduct operations. Facility staffing considerations, including minimum staffing levels, allocation of control functions, overtime restrictions, facility status updates during turnover between shifts, procedures, training, and availability of senior operators during routine operations, will be consistent with American National Standards Institute/American Nuclear Society (ANSI/ANS) standard ANSI/ANS 15.1-2007 (R2018), The Development of Technical Specifications for Research Reactors (ANSI/ANS, 2018a). Details will be provided in the application for the Operating License, consistent with Title10 of the Code of Federal Regulations (10 CFR) 50.34(b)(6)(i).

12.1.4 SELECTION AND TRAINING OF PERSONNEL

Eden will establish and maintain formal and informal indoctrination and training programs for personnel performing, verifying, or managing facility operation activities to ensure that suitable proficiency is achieved and maintained.

Personnel associated with the EIPC must have a combination of academic training, experience, and skills commensurate with the responsibility to provide reasonable assurance that decisions and actions during all normal and abnormal conditions result in the safe operation of the facility.

An indoctrination and training program will be implemented and maintained for personnel performing or managing facility operation activities. ANSI/ANS 15.4-2016, Selection and Training of Personnel for Research Reactors (R2021) (ANSI/ANS, 2021a), will be used in the selection and training of personnel as applicable. Records of personnel training and qualification will be maintained. A description of the training program and the required minimum qualifications for facility staff will be provided in the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(i). The licensed operator training program, including the requalification training program, is described in Section 12.10.

12.1.5 RADIATION SAFETY

The Eden Radiation Protection Program is designed to meet the requirements of 10 CFR Part 19 and 10 CFR Part 20 and developed, documented, and implemented commensurate with the scope and extent of licensed activities for a commercial research utilization and production facility. Procedures and engineering controls are developed, to the extent practicable, based on sound radiation protection principles to achieve occupational doses to workers and doses to members of the public that are ALARA.

Eden will provide sufficient staffing and equipment resources to implement an effective radiation protection program. Further details related to the authority of the Radiation Protection Program staff with respect to facility operations will be provided in the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(i). The Eden Radiation Protection Program is described in Subsection 11.1.2.

12.1.6 HOT CELL FACILITY SAFETY PROGRAM

The Eden HCF Safety Program is developed and integrated with the Radiation Protection Program and other facility safety programs using the methods described in 10 CFR Part 50, 10 CFR 70.61 and 10 CFR 70.62, as appropriate. The Nuclear Criticality Safety Program, as described in Section 6b.5, will be an integral part of the HCF Safety Program.

Further details of the HCF Safety Program will be provided in the application for an Operating License.

Details will address the following:

- Complying with 10 CFR Part 50, 10 CFR 70.61 and 10 CFR 70.62.
- Establishing a records management program.
- Establishing a criticality program and measures.
- Identifying process safety information.
- Identifying radiological, chemical, and facility hazards.
- Establishing management measures.
- Identifying potential accident sequences.
- Applying radiological and chemical consequences and likelihood scenarios.
- Establishing and maintaining records.

12.2 REVIEW AND AUDIT ACTIVITIES

The COO establishes the Review and Audit Committee. The Committee reports directly to and is chaired by the COO, who is responsible for ensuring that appropriate technical expertise is available for review and audit activities. Committee activities are summarized and reported to the Site Director as well as the CEO and COO. The Review and Audit Committee interacts with EIPC and corporate management through the dissemination of meeting minutes and meeting reports. The details of review and audit activities, including the individuals who hold approval authority and mechanisms of communication and interaction with facility and corporate management, will be provided in the application for the Operating License, consistent with 10 CFR 50.34(b)(6)(ii).

12.2.1 COMPOSITION AND QUALIFICATIONS

The composition and qualifications of the Review and Audit Committee will be consistent with ANSI/ANS 15.1-2007 (ANSI/ANS, 2018a), and details will be provided in the application for the Operating License, consistent with 10 CFR 50.34(b)(6)(ii).

12.2.2 CHARTER AND RULES

The Review and Audit Committee charter and rules will include provisions for meeting frequency, quorums, use of subgroups, and minutes, consistent with ANSI/ANS 15.1-2007 (ANSI/ANS, 2018a), and details will be provided in the application for the Operating License, consistent with 10 CFR 50.34(b)(6)(ii).

12.2.3 REVIEW AND AUDIT FUNCTION

The items that must be reviewed and audited by the Review and Audit Committee and the rules for distribution of reports, minutes, and audit findings will be consistent with ANSI/ANS 15.1-2007 (ANSI/ANS, 2018a), and details will be provided in the application for the Operating License, consistent with 10 CFR 50.34(b)(6)(ii).

12.3 PROCEDURES

Operating procedures provide appropriate direction to ensure that the EIPC is operated within its design basis and in compliance with the technical specifications. These procedures are written, reviewed, and approved by appropriate management, as well as controlled and monitored to ensure that the content is technically correct and the wording and format are clear and concise. Activities affecting safety are performed in accordance with approved implementing procedures. The level of detail in a procedure is dependent on the complexity of the task and accounts for the experience, education, and training of the users and the consequences of errors. Expectations for the use of procedures are documented and communicated to facility personnel.

The process required to make changes to procedures, including substantive and minor permanent changes and temporary deviations to accommodate special or unusual circumstances during operation, will be consistent with ANSI/ANS 15.1-2007 (ANSI/ANS, 2018a).

Technical specifications require procedures for the following topics, consistent with Section 6.4 of ANSI/ANS 15.1-2007 (ANSI/ANS, 2018a). Written procedures will be prepared, reviewed, approved, and followed for the following basic topics:

- Startup, operation, and shutdown of the reactor.
- Target (fuel) loading, unloading, and movement within the reactor.
- Target solution fill, draining, and movement within the Eden Medical Isotope Facility (EMIF).
- Maintenance of major components of systems that may have an effect on nuclear safety.
- Surveillance checks, calibrations, and inspections required by the technical specifications.
- Personnel radiation protection, consistent with applicable regulatory guidance. The procedures shall include management commitment and programs to maintain exposures and releases ALARA in accordance with the guidelines of ANSI/ANS-15.11-2016, Radiation Protection at Research Reactors (R2021) (ANSI/ANS, 2021b).
- Administrative controls for operations and maintenance and for the conduct of irradiations that could affect nuclear safety.
- Implementation of required plans (e.g., emergency, security).
- Use, receipt, and transfer of byproduct material.

The specific procedures within these topic areas are developed in accordance with Section 3.5 of the Eden Quality Assurance Program Description (QAPD) provided in Appendix 12B.

A description of the facility procedures, including the review, approval, and changes processes, will be provided in the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(vi).

12.4 REQUIRED ACTIONS

Technical specifications will specify actions to be taken when certain events occur. These are actions to be taken in case of a safety limit violation, if a limiting condition for operation or its associated surveillance requirement is not met, and when other events listed in ANSI/ANS-15.1-2007 occur (ANSI/ANS, 2018a). Details of required actions will be provided in the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(vi).

12.5 REPORTS

Technical specifications will specify the reporting requirements for the facility. These include routine operating reports, changes to the facility or facility organization, special reports for violations of safety limits, and other events listed in ANSI/ANS-15.1-2007 (ANSI/ANS, 2018a). Details of reports will be provided with the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(vi).

12.6 RECORDS

The EIPC Records Management Program includes the identification, generation, authentication, maintenance, and disposition of records. Records are stored in the electronic data management system and may be in the form of logs, data sheets, or other suitable forms. The required information may be contained in single or multiple records or a combination thereof. The Records Management Program is implemented as part of the Eden QAPD described in Section 12.9.

The technical specifications identify records required to be maintained, where and how they are maintained, and their length of retention. The records are grouped by retention period: 1) a period of at least five years (or for the life of the component involved if less than five years), and 2) the lifetime of the EIPC. There are also record retention requirements for training records of reactor operators and senior reactor operators licensed by the United States Nuclear Regulatory Commission (NRC). Details of the EIPC Records Management Program will be provided with the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(vi).

12.7 EMERGENCY PLANNING

The EIPC Emergency Plan describes the essential elements of advance planning and necessary provisions for coping with and mitigating the consequences of emergencies within and beyond the site boundary. The Emergency Plan is primarily focused on situations that may cause or threaten to cause radiological hazards that could affect employee or public health and safety. The Emergency Plan also includes provisions for other on-site emergency situations commensurate with their severity.

The EIPC Emergency Plan is written to conform to 10 CFR Part 50, Appendix E, following the guidance of:

- Regulatory Guide 2.6, Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities, Revision 2.
- ANSI/ANS-15.16-2015, Emergency Planning for Research Reactors (R2024) (ANSI/ANS, 2024).
- ANSI/ANS-8.23-2007, Nuclear Criticality Accident Emergency Planning and Response (R2012) (ANSI/ANS, 2012).
- NUREG-0849, Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors.

In accordance with 10 CFR 50.34(a)(10), a description of the plans for addressing emergencies required of a Preliminary Safety Analysis Report in Appendix E.II, is provided in Appendix 12A of this chapter. Details of the EIPC Emergency Plan will be updated and provided with the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(v).

12.8 SECURITY PLANNING

The EIPC Security Plan will be developed using the guidance provided in Regulatory Guide 5.59, Standard Format and Content for a Licensee Physical Security Plan for the Protection of Special Nuclear Material of Moderate or Low Strategic Significance, Revision 1. A description of the security plan for the facility will be provided with the application for an Operating License consistent with 10 CFR 50.34(c).

12.9 QUALITY ASSURANCE

The Eden QAPD addresses the program requirements in 10 CFR 50.34(a)(7) for establishing and executing a QAP specific to the EIPC. NRC Regulatory Guide 2.5, Quality Assurance Program Requirements for Research and Test Reactors, Revision 1, and ANSI/ANS 15.8-1995, Quality Assurance Program Requirements for Research Reactors (R2018) (ANSI/ANS, 2018b), provide an acceptable method of complying with the QAP requirements of 10 CFR 50.34(a)(7) for the 10 CFR Part 50 utilization facility.

These QAPD requirements are to be applied as applicable to siting, designing, purchasing, fabrication, handling, shipping, receiving, storing, cleaning, erecting, installing, repairing, maintaining, modifying, inspecting, construction, and testing of the EIPC. The QAPD shall be amended when appropriate as the facility proceeds to operation and decommissioning.

The QAPD for the design and construction of the EIPC is provided as Appendix 12B to this chapter.

12.10 OPERATOR TRAINING AND REQUALIFICATION

The EIPC operator training and requalification plan will be developed and implemented in accordance with 10 CFR Part 55 as it pertains to non-power facilities. The qualification process will include passing a comprehensive written exam and an operating test as required by 10 CFR Part 55. The operating training and requalification plan will address both RF operators and HCF operators and will be provided with the application for an Operating License, consistent with 10 CFR 50.34(b)(8) and 10 CFR 50.54.

12.11 STARTUP PLAN

The startup plan for the EMIF utilization facility (RF) and production facility (HCF) will be provided with the application for an Operating License, consistent with 10 CFR 50.34(b)(6)(iii).

12.12 VACATED

12.13 MATERIAL CONTROL AND ACCOUNTING PROGRAM

The Eden MC&A Program will describe the objectives, requirements and methods used by Eden to control and account for special nuclear material during use, storage, and transfer. The MC&A Program will be designed to meet the requirements of a fundamental nuclear material control and accounting plan as described in 10 CFR 74.41(b)(1). The MC&A Program will be provided with the application for an Operating License, consistent with 10 CFR Part 74.

12.14 REFERENCES

ANSI/ANS, 2012. Nuclear Criticality Accident Emergency Planning and Response, ANSI/ANS-8.23-2007 (R2012), American National Standards Institute, American Nuclear Society, approved 2007, reaffirmed 2012.

ANSI/ANS, 2018a. The Development of Technical Specifications for Research Reactors, ANSI/ANS 15.1-2007 (R2018), American National Standards Institute, American Nuclear Society, approved 2007, reaffirmed 2018.

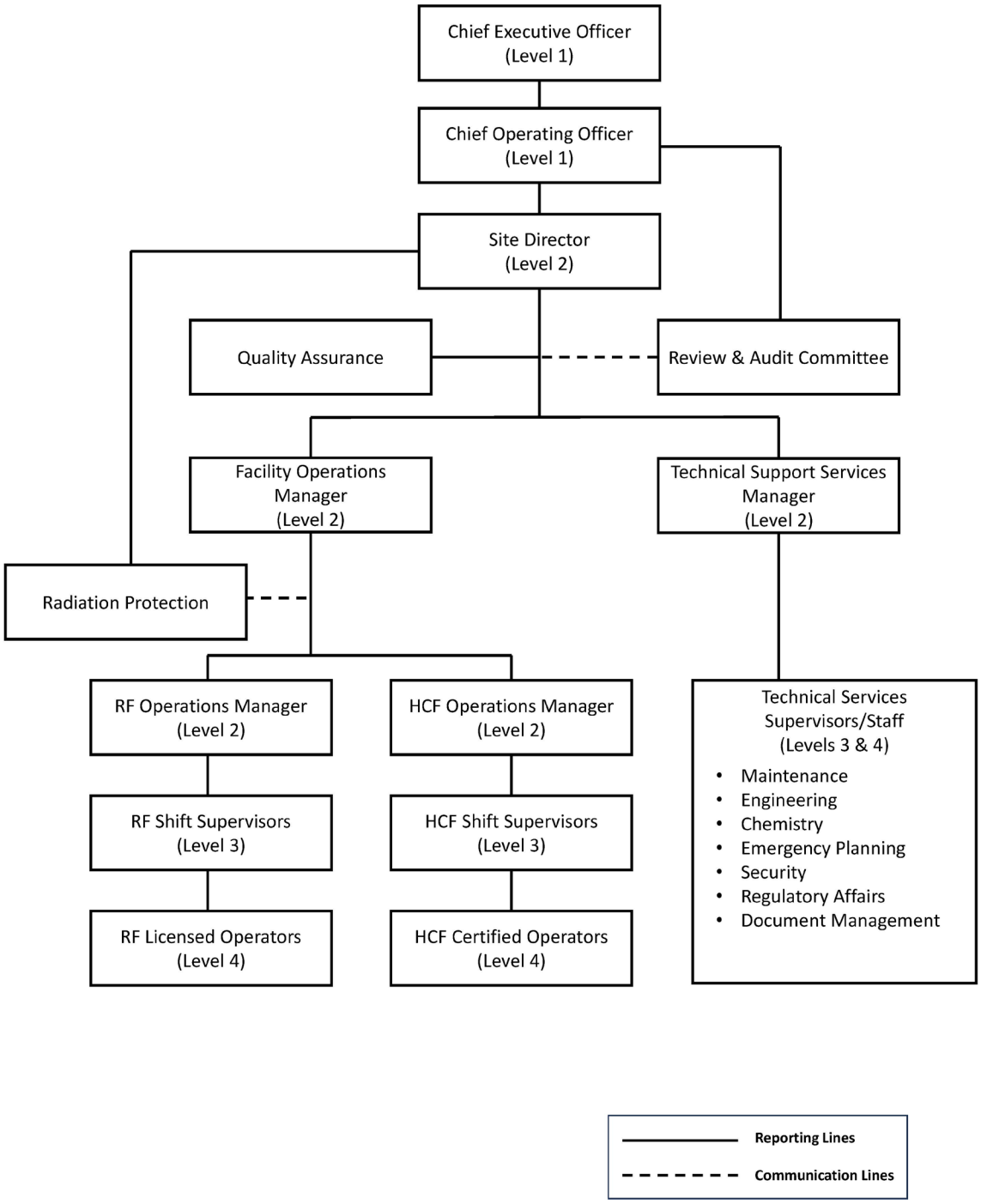
ANSI/ANS, 2018b. Quality Assurance Program Requirements for Research Reactors, ANSI/ANS-15.8-1995 (R2018), American National Standards Institute, American Nuclear Society, approved 1995, reaffirmed 2018.

ANSI/ANS, 2021a. Selection and Training of Personnel for Research Reactors, ANSI/ANS 15.4-2016 (R2021), American National Standards Institute, American Nuclear Society, approved 2016, reaffirmed 2021.

ANSI/ANS, 2021b. Radiation Protection at Research Reactors, ANSI/ANS-15.11-2016 (R2021), American National Standards Institute, American Nuclear Society, approved 2016, reaffirmed 2021.

ANSI/ANS, 2024. Emergency Planning for Research Reactors, ANSI/ANS-15.16-2015 (R2024), American National Standards Institute, American Nuclear Society, approved 2015, reaffirmed 2024.

Figure 12.1-1
EIPC Operational Organizational Structure



APPENDIX 12A

DESCRIPTION OF THE EMERGENCY PLAN

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APPENDIX 12A
DESCRIPTION OF THE EMERGENCY PLAN

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Appendix 12A Description of the Emergency Plan

INTRODUCTION

As required by Title 10 of the Code of Federal Regulations (10 CFR) 50.34(a), this description of the Emergency Plan provides a summary discussion of the preliminary plans for coping with emergencies related to the Eden Isotope Production Complex (EIPC). Appendix E to 10 CFR Part 50, Emergency Planning and Preparedness for Production and Utilization Facilities, establishes requirements for emergency plans to attain an acceptable state of emergency preparedness and to provide reasonable assurance that protective measures can and will be taken to protect the health and safety of workers and the public. This appendix provides the emergency planning related information required for a Construction Permit Application by 10 CFR 50.34(a)(10) and 10 CFR Part 50 Appendix E.II.

12A.1 EIPC DESCRIPTION

The EIPC site is located in Lea County, New Mexico (NM), approximately 1.4 miles (mi.) (2.2 kilometers [km]) southeast of the eastern edge of Eunice, NM, and 1.9 mi. (3.1 km) west of the Texas–New Mexico border. Additionally, the project site is 32 mi. (51 km) west-northwest of Andrews, Texas (TX), and 325 mi. (523 km) southeast of Albuquerque, NM. The nearest large population center (>100,000 population) and commercial airport is the Midland-Odessa, TX, area which is approximately 61 mi. (98 km) to the southeast. Figure 2.1-1 shows the site location in relation to city, county, and state boundaries. The project site is approximately 240 acres (97 hectares).

The project site has the following coordinates:

Latitude/Longitude (Degrees/Minutes/Seconds)	**Universal Transverse Mercator (meters)**	**New Mexico East State Plane Coordinates (feet)**
North 32° 25’ 25.44”	North 3,589,000	Northing 520,095.23
West 103° 5’ 46.14”	East 679,011	Easting 923,087.04

The site is located 0.6 mi. (1 km) south of New Mexico Highway 176 (NM-176) and 1.9 mi. (3.1 km) southeast of the intersection of New Mexico Highway 18 and NM-176.

The EIPC site is generally flat with slight undulations in elevation. Surrounding properties consist of undeveloped land immediately to the north, east, south, and west. A network of oil wells is present to the immediate south and west of the project site. The EIPC site is also located in close proximity to several other facilities in the nuclear industrial complex, most notably, the Urenco USA (URENCO) national enrichment facility, approximately 1.3 mi. (2.1 km) to the north-northeast, and the Waste Control Specialists facility, approximately 2.6 mi. (4.2 km) east-northeast in Andrews County, TX.

The EIPC is designed to produce molybdenum-99 (Mo-99), iodine-131, and xenon-133 through the fission process and produce other isotopes, such as lutetium-177, through neutron activation. The decay product of Mo-99, technetium-99m, is used for a variety of nuclear medicine diagnostic procedures.

The EIPC consists of a small, non-power, open-pool Reactor Facility (RF), Hot Cell Facility (HCF), a target fabrication facility, and a waste packaging, handling, and storage facility, in

addition to administrative and storage space. A preliminary general arrangement drawing of the EIPC and site layout is provided in Figure 12A.1-1.

The major structures consist of the following:

- Administration Office Complex (AOC).
- Access Control Center (ACC).
- Production Office Complex (POC).
- Production Warehouse (PWH).
- Eden Medical Isotope Facility (EMIF).

The AOC is a standard commercial office building. The AOC is located outside the operations boundary to reduce the need to bring non-production staff into the operations area. The purpose of the AOC is to house staff required for site management and oversight of EIPC operations. Estimated size: 9000 gross square feet (GSF) (836 gross square meters [GSM]).

The ACC serves as the single access point to control pedestrian and vehicular traffic into and out of the operations area. The ACC is located at the operations area boundary fence. It houses the Emergency Support Center (ESC), [[ ]][SRI]. The ACC also includes an evacuation center that also serves as a conference room. Estimated size: 2000 GSF (186 GSM).

The POC is a commercial office building, located inside the operations area, near the EMIF, to house production staff required for production management and operations. Estimated size: 8000 GSF (743 GSM).

The PWH is a stand-alone, high-volume, slab on grade, pre-engineered metal building, located inside the operations area, to be used for high-volume storage and staging of materials and equipment necessary for the operation of the site. This facility houses the warehouse supervisor and warehouse staff. Estimated size: 10,000 GSF (929 GSM).

The EMIF consists of the RF and the HCF. The RF houses the 1.8-megawatt all-target, non-power, open stainless steel lined pool type reactor. The all-target reactor consists of a hexagonal array of low-enriched uranium (LEU) fuel bearing targets, surrounded by a beryllium reflector located near the bottom of a stainless-steel lined water pool. Target cooling is provided by circulation of pool water by natural convection. The pool water is cooled by the primary coolant system. The reactor system is similar to a TRIGA (Training, Research, Isotopes Production, General Atomics) reactor operated in the steady state mode, except for the fueled target design. Fresh targets are loaded into the fuel grid, irradiated in the reactor, and removed and transferred under water via the transfer canal to the target receipt box of the HCF for processing. Target processing is performed remotely in the target processing canyon, which contains separate stainless steel confinement boxes dedicated to different functional stages of the process. The stages are 1) target receipt, 2) target disassembly, foil dissolution, extraction of LEU, Mo-99, noble gases, and halogens, and waste preparation, 3) product and LEU purification, 4) product and LEU packaging, 5) waste packaging, and 6) recycle of LEU into target material. A waste storage canyon is also included in the HCF. The fission product waste is neutralized, solidified, stored in waste drums for radioactive decay, and subsequently shipped

to a disposal site as Class C low-level waste. A target fabrication area is also included in the HCF. Target fabrication consists of blending the recycled oxide special nuclear material with fresh target material, reducing the uranium oxide to metal ingots, rolling and forming the ingots into nickel coated foil, and cladding the foil with aluminum and forming the targets.

A description of the project site and surrounding area is provided in Chapter 1. Additional details are provided in Section 2.1.

The controlled area is established in accordance with the American National Standards Institute/American Nuclear Society (ANSI/ANS) 15.7-1977, Research Reactor Site Evaluation (R1986) (ANSI/ANS, 1986); ANSI/ANS-15.16-2015, Emergency Planning for Research Reactors (R2024) (ANSI/ANS, 2024); and 10 CFR 20.1003. The project site boundary delineates the extent of the area that is subject to the facility operating license. The EIPC site boundary is coincident with the controlled area boundary.

A rectangle surrounding the project site center point within which all safety-related structures are located gives the approximate location and size of the operations boundary in accordance with ANSI/ANS 15.7-1977 (ANSI/ANS, 1986) and ANSI/ANS 15.16-2015 (ANSI/ANS, 2024). As shown in Figure 12A.1-1, the Emergency Planning Zone (EPZ) is coincident with the site boundary and is informed by the guidance in United States Nuclear Regulatory Commission (NRC) NUREG-0849, Standard Review Plan for Review and Evaluation of Emergency Plans for Research and Test Reactors; ANSI/ANS 15.16-2015 (ANSI/ANS, 2024); NRC Regulatory Guide 2.6, Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities, Revision 2; 10 CFR 50.54; and Appendix E to 10 CFR Part 50.

12A.2 ORGANIZATION AND RESPONSIBILITIES

12A.2.1 NORMAL FACILITY OPERATING ORGANIZATION

The initial response to any emergency is by the normal EIPC on-shift organization present at the site. The minimum staff required to conduct immediate emergency operations is maintained at the facility on a continuous basis. Off-shift personnel may be called in to assist as required.

Staffing and organization responsibilities during normal facility operations, including reporting relationships, are described in Section 12.1 and shown in Figure 12.1-1. Facility administrative procedures provide the details of the normal facility organization, including reporting relationships.

As described in Section 2.1, the EPZ is coincident with the site boundary. No off-site emergency plan actions are required.

12A.2.2 FACILITY EMERGENCY RESPONSE ORGANIZATION

The regulations in 10 CFR Part 50, Appendix E.II.A require information regarding on-site and off-site organizations for coping with emergencies and the means for notification, in the event of an emergency, of persons assigned to the emergency organizations.

The senior emergency plan response qualified individual on-shift at the onset of an emergency, or, if no qualified person is at the facility, the senior person on shift, is responsible for assessing and declaring an emergency and assuming command and control responsibilities following an emergency declaration. Upon declaration of an emergency, designated members of the normal

staff fulfill corresponding roles in responding to the emergency. For example, operations personnel perform facility operations, health physics personnel perform radiation protection activities, security personnel perform security activities, and engineering personnel perform facility assessment and technical support for operations.

Additional personnel may be designated by Eden management as emergency responders providing special expertise deemed beneficial, but not mandatory, to the planned response. The individuals assigned as emergency response personnel are designated by Eden management based on the technical requirements and training requirements of the position. The primary responsibilities of key emergency response personnel are outlined below. The additional roles and responsibilities for emergency response personnel are provided in the application for an Operating License.

12A.2.3 AUTHORITIES AND RESPONSIBILITIES OF FACILITY EMERGENCY RESPONSE PERSONNEL

12A.2.3.1 Emergency Director

In the event of an emergency, the senior emergency plan response qualified individual on-shift at the onset of an emergency, or, if no qualified person is at the facility, the senior person on shift, serves as the Emergency Director. The senior person on shift temporarily serves in this role until a relief Emergency Director arrives on-site. Only individuals who have formally qualified as Emergency Director are authorized to assume the Emergency Director responsibilities. The duties of the Emergency Director may be assumed by any of the individuals authorized for that role upon their arrival at the facility and may be passed from one individual to another, but only after the individual assuming the role is thoroughly briefed on status of the event and the currently proposed plan of action.

The responsibilities of the Emergency Director are as follows:

- Declare and classify the emergency.
- Direct emergency operation and ensure proper implementation of the emergency response plan.
- Ensure that any necessary NRC notifications are made in accordance with the applicable requirements.
- Authorize emergency workers to incur radiation exposures in excess of normal occupational limits, with the concurrence of the Radiation Safety Officer (RSO), if available. This function cannot be delegated.
- Terminate the emergency and initiate recovery operations.
- Assess conditions in the facility after termination of the emergency to determine the proper course of further recovery actions.
- Authorize an evacuation of all or part of the site.
- Authorize reentry into the facility (or portion thereof) that required evacuation during the emergency.
- Establish and coordinate recovery/re-entry efforts.

- Evaluate the causes of the emergency and recommend corrective actions before returning the facility to a normal operating status.
- Coordinate emergency response actions with the off-site emergency support services.
- Request augmented support as appropriate.

Communication of emergency information to the media is the primary responsibility of the Emergency Director with the assistance of Eden communications staff.

The emergency classification levels and the associated protective actions are provided in the application for the Operating License.

12A.2.3.2 Radiation Safety Officer

In the event of an emergency, the RSO or senior health physics person on-shift or on-call is responsible for the radiological health physics aspects of the emergency.

The responsibilities of the RSO are to:

- Evaluate public and personnel doses received during the incident.
- Assess subsequent potential doses and recommend protective actions, as appropriate.
- Assist the Emergency Director and help determine the course of further action.

12A.2.4 MEANS FOR NOTIFICATIONS

Eden provides the capability for 24-hour notification to on-site and off-site organizations, including a primary and backup means, to accomplish the required notifications.

12A.3 EMERGENCY SUPPORT ORGANIZATIONS

Appendix E.II.B requires information regarding contacts and arrangements made and documented with agencies with responsibility for coping with emergencies, including identification of the principal agencies. This section describes the authorities, responsibilities, and support functions of federal, state, county, and local governmental agencies in an emergency situation.

12A.3.1 NUCLEAR REGULATORY COMMISSION

The NRC is the Coordinating Agency/Lead Federal Agency for incidents that occur at fixed facilities or during activities licensed by the NRC. Notification procedures (e.g., telephone, electronic messaging, written reports, etc.) are implemented as required. The response provided by the NRC is described in NUREG-0728, NRC Incident Response Plan, Revision 4.

12A.3.2 COORDINATION WITH PARTICIPATING STATE AGENCIES

12A.3.2.1 State of New Mexico Interfaces

The New Mexico Department of Homeland Security and Emergency Management (NMDHSEM) is responsible for coordinating the state emergency response. The State of New Mexico All-Hazard Emergency Operations Plan provides guidance on incidents or disasters, including

those involving hazardous materials and radiological releases. By state law, the New Mexico State Police have Incident Command responsibility for all hazardous material and radiation incidents in the state.

The NMDHSEM is notified of an emergency declaration using approved and authorized procedures. The methods used to notify the department and the information provided to them are established in coordination with NMDHSEM.

12A.3.2.2 State of Texas Interfaces

Because of the proximity of the facility to the Texas state border, Texas agencies are notified per the notification plan of a declared emergency. Notifications are made to the Andrews County Sheriff's Office and the Texas State Operations Center – Austin.

12A.3.3 LEA COUNTY OFF-SITE ASSISTANCE

12A.3.3.1 Lea County Office of Emergency Management

The Lea County Emergency Manager has the primary responsibility for handling emergency response and support operations at the local level. The Lea County Office of Emergency Management organization is responsible for coordinating major emergencies, disaster response, volunteer organizations, and recovery efforts in support of county and local governments. The Lea County Office of Emergency Management provides additional resources to the response effort when such assistance is sought by local emergency support agencies.

12A.3.3.2 Lea County Sheriff's Office

The Lea County Sheriff's Office assists in law enforcement activities responding to the facility as requested by the City of Eunice Police Department.

12A.3.3.3 Lea County Communication Authority

The Lea County Communication Authority (LCCA) operates the Lea County 911 Call Center, which covers the cities of Hobbs, Lovington, Eunice, Jal, and Tatum. Call Center dispatchers have the capability to deploy emergency and non-emergency agencies to all parts of Lea County.

When contacted, the LCCA dispatches fire, Emergency Medical Services, and local law enforcement personnel.

12A.3.4 LOCAL OFF-SITE ASSISTANCE TO THE FACILITY

Mutual aid agreements and/or Memoranda of Understanding are to be reached with the following local emergency support organizations:

- City of Eunice Fire and Rescue Services.
- City of Eunice Police Department.
- Lea County Sheriff's Office.
- City of Hobbs Fire Department.

- Covenant Health Hobbs Hospital.
- Permian Regional Medical Center.

These agreements are documented, integrated with the communication plan, and included in the application for an Operating License to ensure a clear understanding of the emergency support responsibilities of each agency.

These arrangements are similar to the arrangements currently in place and documented in the nearby URENCO national enrichment facility emergency plan.

12A.3.4.1 Eunice Fire and Rescue Services

Fire Support: If fire support is needed, the Lea County 911 Communications Authority dispatches Eunice City Fire and Rescue Services personnel. The nearest Eunice Fire Station is approximately 4.8 mi. (7.7 km) from the EIPC. If additional fire equipment is needed, or if the Eunice Fire and Rescue Services are unavailable, the Lea County 911 Communications Authority activates existing mutual aid agreements with neighboring communities for dispatch of fire equipment and personnel to the site. In instances where radioactive/hazardous materials are involved, the Eden Emergency Director or designee ensures information and assistance is provided to the responding off-site personnel. Information specific to the EIPC is located in the Lea County 911 Communications Authority and Eunice Fire and Rescue Services response information binder.

First Aid Support: If immediate on-site first aid support is needed, the Lea County 911 Communications Authority dispatches Eunice Fire and Rescue Services. The organization employs emergency medical technicians and individuals trained in first aid and qualified to provide immediate medical assistance required for radiological emergencies on-site.

Ambulance Services: Transporting an injured person from the EIPC to an off-site medical facility is normally performed by Eunice Fire and Rescue Services ambulances dispatched by the Lea County 911 Communications Authority. In the event the Eunice Fire and Rescue Services ambulances are not available, the LCCA activates existing mutual aid agreements with neighboring communities for dispatch of an ambulance to the EIPC.

Hazardous Materials Response: If hazardous materials assistance is needed, the Eunice Fire and Rescue Hazardous Material (HazMat) Response Team is dispatched by the LCCA or by the local Fire Department Incident Commander.

12A.3.4.2 Eunice Police Department

If law enforcement support is needed, the Lea County 911 Communications Authority dispatches law enforcement personnel. If needed, the Eunice Police Department contacts the Lea County Sheriff's Office, which maintains sheriff's deputies in the Eunice area that can respond if additional resources are needed. Emergency law enforcement support may include the following:

- Responding to emergencies at the facility, as necessary.
- Responding to emergencies arising from a threatened or actual breach in the physical security of the facility in accordance with the standard operating procedures in the EIPC Security Plan.

- Assisting security personnel by monitoring and maintaining the security of the facility after an emergency evacuation.
- Coordinating with other law enforcement agencies, as needed.
- Providing traffic control and controlling access to areas affected by the emergency.

12A.3.4.3 Medical Services

Covenant Health Hobbs Hospital, located in Hobbs, is utilized for treatment of personnel who cannot be treated properly at the facility. Permian Regional Medical Center, located in Andrews, TX, provides back-up support to Covenant Health Hobbs Hospital for treatment of personnel who cannot be treated properly at the facility.

12A.4 PROTECTIVE MEASURES

10 CFR Part 50 Appendix E.II.C requires information with respect to protective measures to be taken within the site boundary and within each EPZ to protect health and safety in the event of an accident, procedures by which these measures are to be carried out, and the expected response of off-site agencies in the event of an emergency. Because the EIPC EPZ is coincident with the owner controlled area (site boundary), only protective measures within the site boundary are described.

The method for activating the emergency organization is described in the application for an Operating License. The plan specifies the location(s) of current notification lists, specific actions to notify and mobilize the emergency organization, and the applicable off-site support organizations for each emergency class.

Steps for taking protective action within the EPZ can be summarized as follows:

a. The individual who initially confirms an emergency situation immediately contacts the reactor control room and describes the emergency.
b. The Emergency Director is responsible for assessing and declaring an emergency and classifies the emergency.
c. The NRC is notified of the class of emergency by the Emergency Director when required by applicable licenses and regulations.
d. The Emergency Director mobilizes that part of the facility organization appropriate for the emergency.
e. The 24-hour per day emergency call list for emergency response personnel is posted in the facility, including the reactor control room.
f. Required off-site support agencies are then mobilized (normally by telephone) by the Emergency Director.
g. Corrective and protective actions are implemented in accordance with site procedures, as required for the situation, at the discretion of the Emergency Director.

Protective measures that may be taken within the EIPC controlled area during an emergency include the following:

- Performing first aid.

- Relocating personnel away from contaminated or hazardous areas.
- Establishment of restricted areas.
- Implementation of contamination control measures.
- Site evacuation of non-essential personnel.

The public address system and action specific alarms (e.g., site evacuation) can be used to communicate appropriate protective actions.

12A.5 FIRST AID, DECONTAMINATION, AND EMERGENCY TRANSPORTATION

10 CFR Part 50 Appendix E.II.D requires discussion of features of the facility to be provided for on-site emergency first aid and decontamination and for emergency transportation of on-site individuals to off-site treatment facilities.

The measures that are used to provide necessary assistance to persons injured or exposed to radiation are identified in the Operating License Application. The capabilities for decontamination, administering first aid, and transporting injured personnel along with the arrangements for medical treatment are described.

The following items are included:

- First aid training and capabilities of the emergency organization.
- Availability of showers, personnel first aid, and decontamination kits within the facility.
- Capabilities for decontaminating personnel for their own protection in an area isolated from other activities to prevent or minimize further spread of contamination.
- Assessment of the responding medical staff regarding the nature and extent of worker injuries, including the level of contamination, if applicable.
- Arrangements for transporting injured personnel who also may be contaminated to medical treatment facilities.
- Arrangements for local hospital and medical services.
- Assurance that hospital and medical services can provide the required services, and those persons providing them are available, prepared, and qualified to manage radiological emergencies; written agreements with respect to arrangements made for hospital and medical services are included.

The principal state and local agencies/organizations having responsibilities for radiological or other hazardous material emergencies for the facility are:

- NMDHSEM.
- New Mexico State Police.
- Lea County Emergency Management Agency.

12A.6 OFF-SITE TREATMENT

10 CFR Part 50 Appendix E.II.E requires information regarding provisions to be made for emergency treatment at off-site facilities of individuals injured as a result of licensed activities.

Subsection 12A.3.4.3 includes a listing of off-site medical facilities to be used by Eden.

12A.7 TRAINING

10 CFR Part 50 Appendix E.II.F requires discussion of training for employees, including those assigned specific authority and responsibility in the event of an emergency, and for other persons who are not employees of the licensee but whose assistance may be needed in the event of a radiological emergency.

The content of the training program includes the overall Emergency Plan and the relevant implementing procedures. The following are identified or described, as applicable, to demonstrate emergency preparedness training in the Operating License Application:

- Programs to initially train and periodically retrain on-site personnel for participation in the emergency plan and to provide specified training to on-site personnel to maintain their ability to perform their specific emergency assignments. Personnel involved in the training program include facility personnel responsible for decision-making and transmitting emergency information.
- Training as appropriate, such as briefings or site orientation visits, for off-site personnel and agencies whose assistance is needed in responding to an emergency.
- On-site emergency drills to be conducted as action drills with each required emergency measure being executed as realistically as is reasonably possible, including the use of appropriate emergency equipment.
- Provision for critiques of all drills, including timely evaluation of observer comments, correction of identified deficiencies, and revision of implementing procedures, as needed.

12A.8 EVACUATION

10 CFR Part 50 Appendix E.II.G requires discussion of preliminary analyses projecting the time and means to be employed in the notification of state and local governments and the public in the event of an emergency.

This requirement is not applicable to the EIPC, as it applies to power reactors. In addition, the EIPC EPZ is coincident with the site boundary and there are no transient or permanent populations within the EPZ. Therefore, no analysis of evacuation steps is required, and this requirement is not applicable.

State and local governments and the public are notified as appropriate, in accordance with the communications plan.

12A.9 EMERGENCY EQUIPMENT AND FACILITIES

10 CFR Part 50 Appendix E.II.H requires discussion of preliminary analyses reflecting the need to include facilities, systems, and methods for identifying the degree of seriousness and potential scope of radiological consequences of emergency situations within and outside the site boundary, including capabilities for dose projection using real-time meteorological information and for dispatch of radiological monitoring teams within the EPZ; and a preliminary analysis reflecting the role of the on-site technical support center (TSC) and the emergency operations facility (EOF) in assessing information, recommending protective action and disseminating information to the public.

As discussed earlier, the EIPC EPZ is the site boundary. Facilities, systems, and methods for identifying the seriousness of the radiological consequences of emergency situations are available. Because there is no off-site release above the Environmental Protection Agency Protective Action Guides, there is no need for off-site monitoring teams, a TSC, or EOF. Timely notification is made to the public for a declared emergency.

The systems of emergency communications that are available to communicate instructions and information both on-site and off-site throughout the course of the emergency are identified in the Operating License Application. Eden shall establish reliable primary and backup means of communication (e.g., public telephone and radio) that are compatible with local off-site emergency support groups.

12A.9.1 CONTROL ROOM

The reactor control room is the centralized on-site location within the operations boundary from which the EMIF is operated. The reactor control room is provided with communications equipment to communicate within and outside the facility, including commercial telephones, base station radios, and the ability to broadcast on the public address system.

During an emergency, the reactor operator(s) scram the reactor and evacuate with all other personnel to the ACC evacuation center. No one remains in the reactor control room.

12A.9.2 EMERGENCY SUPPORT CENTER

The ESC is an on-site facility from which effective direction and control can be exercised during an emergency when activated.

The ESC is located within the ACC. The ACC serves as the single access point to control pedestrian and vehicular traffic into and out of the operations area. As shown in Figure 12A.1-1, the ACC is located at the operations area boundary fence. It houses the [[ ]]^{SRI}.

The ESC is equipped with communications equipment to communicate within and outside the facility, including commercial telephones, base station radios, and the ability to broadcast on the public address system.

The ESC contains the following supplies and equipment:

- A controlled copy of the Emergency Plan Implementing Procedures, facility operating and emergency operating procedures, and current notification rosters.
- Documentation/layout of the facilities showing chemical and radiological hazard areas of each facility and their contents.
- First aid equipment.
- Handheld radios or other means of communication equipment.
- Handheld lights.
- Respirators.
- Portable radiation monitoring equipment.
- Electronic dosimeters for use by emergency personnel.
- A supply of anti-contamination clothing.

12A.9.3 ASSESSMENT FACILITIES AND EQUIPMENT

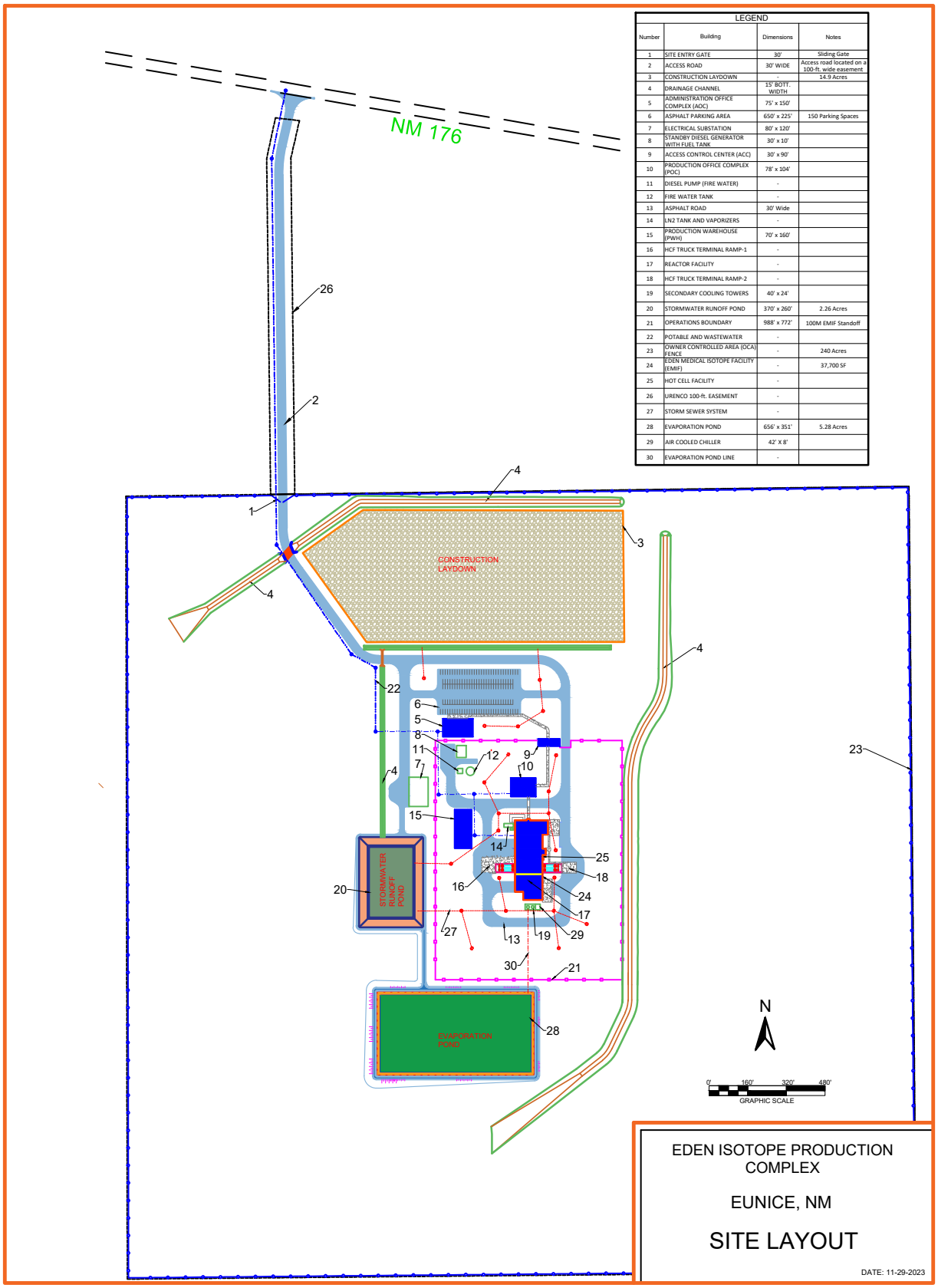
Monitoring systems and laboratory facilities that are used to determine the need to initiate emergency measures as well as those to be used for continuing assessment are identified in the Operating License Application. These monitoring systems may consist of equipment such as portable and fixed radiological monitors, personnel monitoring, sampling equipment, criticality alarms, earthquake sensors, fire and combustion product detectors, and process monitors that provide pertinent facility system or status information.

12A.10 REFERENCES

ANSI/ANS, 1986. Research Reactor Site Evaluation, ANSI/ANS-15.7-1977 (R1986), American National Standards Institute, American Nuclear Society, approved 1977, reaffirmed 1986.

ANSI/ANS, 2024. Emergency Planning for Research Reactors, ANSI/ANS-15.16-2015 (R2024), American National Standards Institute, American Nuclear Society, approved 2015, reaffirmed 2024.

Figure 12A.1-1
Site Layout and Boundaries



LEGEND

Number	Building	Dimensions	Notes
1	SITE ENTRY GATE	30'	Sliding Gate
2	ACCESS ROAD	30' WIDE	Access road located on a 100-ft. wide easement
3	CONSTRUCTION LAYDOWN		14.9 Acres
4	DRAINAGE CHANNEL	15' BOTT. WIDTH	
5	ADMINISTRATION OFFICE COMPLEX (ADC)	75' x 150'	
6	ASPHALT PARKING AREA	650' x 225'	150 Parking Spaces
7	ELECTRICAL SUBSTATION	80' x 120'	
8	STANDBY DIESEL GENERATOR WITH FUEL TANK	30' x 10'	
9	ACCESS CONTROL CENTER (ACC)	30' x 90'	
10	PRODUCTION OFFICE COMPLEX (POC)	78' x 104'	
11	DIESEL PUMP (FIRE WATER)	-	
12	FIRE WATER TANK	-	
13	ASPHALT ROAD	30' Wide	
14	LN2 TANK AND VAPORIZERS	-	
15	PRODUCTION WAREHOUSE (PWH)	70' x 160'	
16	HCF TRUCK TERMINAL RAMP-1	-	
17	REACTOR FACILITY	-	
18	HCF TRUCK TERMINAL RAMP-2	-	
19	SECONDARY COOLING TOWERS	40' x 24'	
20	STORMWATER RUNOFF POND	370' x 260'	2.26 Acres
21	OPERATIONS BOUNDARY	988' x 772'	100M EMIF Standoff
22	POTABLE AND WASTEWATER	-	
23	OWNER CONTROLLED AREA (OCA) FENCE	-	240 Acres
24	EDEN MEDICAL ISOTOPE FACILITY (EMIF)	-	37,700 SF
25	HOT CELL FACILITY	-	
26	URENCO 100-ft. EASEMENT	-	
27	STORM SEWER SYSTEM	-	
28	EVAPORATION POND	656' x 351'	5.28 Acres
29	AIR COOLED CHILLER	42' X 8'	
30	EVAPORATION POND LINE	-	

APPENDIX 12B

QUALITY ASSURANCE PROGRAM DESCRIPTION FOR DESIGN, LICENSING AND CONSTRUCTION OF THE EDEN ISOTOPE PRODUCTION COMPLEX

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Eden Radioisotopes, LLC

Quality Assurance Program Description for Design, Licensing and Construction of the Eden Isotope Production Complex

Document No. PG-NQ-02-01

Revision 2

Effective Date 12/19/2025

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eden Precision Science. Human Impact.	**PROGRAM**	Document No:	PG-NQ-02-01
		Revision:	2
		Effective Date:	12/19/2025
		Page 1 of 22	
Title:	**Quality Assurance Program Description for Design, Licensing and Construction of the Eden Isotope Production Complex**		

Preparer:

James Saldarini	JCSaldarini	12/19/2025
Licensing Director	Sign	Date

Approved:

Richard Weis	Rick Weis	12/19/2025
Quality Assurance Director	Sign	Date

Approved:

Chris Wagner	Chris Wagner	12/19/2025
Chief Operating Officer	Sign	Date

Revision	Effective Date	Description of Revision
0	10/28/2020	Initial Issue
1	10/8/2021	• Added a Policy Statement • Document numbering change to align with Eden numbering • Editorial and formatting changes • Updated to read to ANSI 15.8 • Updated language pointing to EUF, EPF, and EFTA to Radionuclide Processing Area as necessary • Updated TOC to show 2nd level steps • Changed Enclosures to Exhibits • Added EPRI audit/assessment direction for pandemics • Removed details in Section 4 as that will be part of operating license submittal.
2	12/19/2025	• Updated title of document • Updated Organization Chart and Position Descriptions • Miscellaneous editorial and format changes

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eden Precision Science. Human Impact.	**PROGRAM**	Document No:	PG-NQ-02-01
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Title:	**Quality Assurance Program Description for Design, Licensing and Construction of the Eden Isotope Production Complex**		

POLICY STATEMENT

Eden Radioisotopes, LLC (Eden) shall design, procure, construct, operate and decommission the Eden Isotope Production Complex (Eden facility) in a manner that shall ensure the health and safety of the public and workers. These activities shall be performed in compliance with the requirements of the Code of Federal Regulations (CFR), the applicable U.S. Nuclear Regulatory Commission (NRC) Construction Permit and Facility Operating License, and applicable laws and regulations of the state of New Mexico and local governments.

The Eden Quality Assurance Program (QAP) consists of this Quality Assurance Program Description (QAPD) and the associated implementing documents. Together they provide for control of Eden activities that affect the quality of safety-related nuclear facility structures, systems, and components (SSCs) and include all planned and systematic activities necessary to provide adequate confidence that such SSCs shall perform satisfactorily in service. The QAPD may also be applied to certain equipment and activities that are not safety-related, but support safe facility operations, or where other NRC guidance references program requirements.

The QAPD is the top-level policy document that establishes the manner in which quality is to be achieved and presents Eden's overall philosophy regarding achievement and assurance of quality. Implementing documents assign more detailed responsibilities and requirements and define the organizational interfaces involved in conducting activities within the scope of the QAP. Eden applies a graded approach to quality consistent with importance to safety and reliability. Eden management establishes overall expectations for obtaining the desired end result and remains accountable to ensure that the requirements of this QAPD are met. Compliance with the QAPD and implementing documents is mandatory for personnel directly or indirectly associated with the implementation of this QAPD.

Signed: Date: 12/19/2025

Carrie Freeman

Chief Executive Officer

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Title:	**Quality Assurance Program Description for Design, Licensing and Construction of the Eden Isotope Production Complex**		

1.0 PURPOSE

Eden Radioisotopes, LLC (Eden) intends to submit applications to the U.S. Nuclear Regulatory Commission (NRC) seeking approval of licenses to construct and operate a facility for the sole purpose of producing urgently needed medical isotopes, which are in short supply around the globe and produced primarily in foreign countries. As a domestic medical isotope production facility, the Eden facility will enhance both national security and public health. The facility will produce Molybdenum-99 (Mo-99) through fission of uranium and separation of the Mo-99 from the uranium and other fission products (fission process). In addition to the production of Mo-99, the Eden facility shall have the capability of producing Iodine-131 and Xenon-133 through the fission process and will also produce other isotopes such as Lutetium-177 through neutron activation. The Eden facility will enable reliable, concurrent access to Mo-99 and Lu-177, which are essential for cancer diagnosis and treatment.

The Eden facility consists of a small, non-power, open pool reactor utilization facility, a separation processing hot cell production facility, a target fabrication facility, and a waste packaging, handling, and storage facility in addition to administrative and storage areas. The reactor utilization facility, the hot cell production facility and the waste packaging, handling and storage facility shall be licensed under Title 10 of the Code of Federal Regulations (10 CFR) Part 50 and the target fabrication facility shall be licensed at the operating license stage under 10 CFR Part 70.

2.0 INTRODUCTION

2.1 Overview

This Quality Assurance Program Description (QAPD) addresses the program requirements in 10 CFR 50.34(a)(7) for establishing and executing a Quality Assurance Program (QAP) specific to Eden. NRC Regulatory Guide 2.5,Revision 1, "Quality Assurance Program Requirements for Research and Test Reactors," and American National Standards Institute/American Nuclear Society standard (ANSI/ANS) 15.8-1995 (R2005;R2013), "Quality Assurance Program Requirements for Research Reactors," provide an acceptable method of complying with the quality assurance program requirements of 10 CFR 50.34(a)(7) for the 10 CFR Part 50 utilization facility.

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2.2 Scope

The QAPD describes the administrative and engineered controls for ensuring compliance with ANSI/ANS 15.8-1995 (R2005;R2013) requirements. These QAPD requirements are to be applied as applicable to siting, designing, purchasing, fabrication, handling, shipping, receiving, storing, cleaning, erecting, installing, repairing, maintaining, modifying, inspecting, construction and testing of the Eden facility. The QAPD shall be amended when appropriate as the facility proceeds to pre-operational activities, including training, operation, and decommissioning.

2.3 Application

The QAP applied by Eden to its activities shall be consistent with the importance of the activities to safety and reliability. Activities included in this QAP shall be, as a minimum, those affecting the quality and performance of safety-related Structures, Systems and Components (SSCs).

Eden shall apply a graded approach to those items and activities that could affect the quality of SSCs, and other components not specifically designated as safety-related. A Quality Level (QL) description (Exhibit A) is used to ensure quality requirements are understood and specified for each SSC. Applicable activities shall be performed in accordance with the graded approach.

Eden shall develop and implement the QAP beginning with the design, siting, and construction phase of the facility. This QAP shall focus on the development of appropriate controls to ensure the facility is properly designed and fabricated to meet Eden requirements. Most of these controls shall provide documentation that attests that the facility quality supports an operating license.

Following facility construction and commissioning, the focus of this quality program shifts to establishing those controls that ensure proper and reliable facility operations. All the program provisions established during the design and construction phase remain in place but will change in level of implementation appropriate to support facility operations; each portion of design, construction, and modifications would be implemented only as necessary. Quality assurance requirements for operations will be addressed in the facility operating license application. The QAP implementation strategy shall support the graded approach by considering the tangible and intangible attributes of replacement costs and schedule delays.

2.4 Definitions

Definitions are listed to provide uniform interpretation of terms and phrases used in this document. Definitions from ANSI/ANS 15.8-1995 (R2005;R2013) not applicable

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to Eden are not used in the QAPD. Additional definitions applicable to Eden activities are added to the QAPD.

Term	Definition
Commissioning	The process during which constructed reactor SSCs are made operational and verified to meet design requirements.
Corrective Action	Measures taken to rectify conditions adverse to quality, and where necessary, to prevent repetition.
Document	Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results.
Engineered Safety Features (ESFs)	ESFs are active or passive features designed to mitigate the consequences of accidents and to keep radiological exposures to the public, the facility staff and the environment within acceptable values. ESFs are managed at the same level as Safety-Related Items.
Experiment	Any operation, hardware, or target (excluding devices such as detectors, foils, etc.), that is designed to investigate non-routine reactor characteristics or that is intended for irradiation within the pool, on or in a beamport or irradiation facility, and that is not rigidly secured to a core or shield structure so as to be a part of their design.
Licensed Operator	An individual licensed by the NRC to carry out the duties and responsibilities associated with the position of reactor operator or senior reactor operator.
Maintenance	Those activities necessary to maintain operability or restore systems to within specified design limits. Maintenance consists of repair, rework, replacement, adjustment, cleaning, or other actions necessary to maintain an item in or restore an item to an acceptable condition.
Management	Management means those persons within the Eden organization whose responsibility and authority includes the QAP. The levels of management are as described in American National Standard for Development of Technical Specifications for Research Reactors, ANSI/ANS-15.1-2007 (R2018).
Modification	A change in the physical design or functional characteristics of an SSC.

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Term	Definition
Non-power Reactor	See "research reactor".
Procedure	A document that specifies or describes how an activity is to be performed.
Quality	The degree to which an item or process meets or exceeds the user's requirements and expectations.
Quality Assurance	Those planned and systematic actions necessary to provide adequate confidence that the SSCs will perform satisfactorily in service.
Research Reactor	A device designed to support a self-sustaining neutron chain reaction for research, development, educational, training, or experimental purposes, and that may have provisions for the production of radioisotopes.
Safety-related Items	Those physical SSCs whose intended functions are to prevent accidents that could cause undue risk to the health and safety of workers and the public, or to the research reactor's programs; and to control or mitigate the consequences of such accidents.
Shall, should and may	The word "shall" is used to denote a requirement; the word "should" to denote a recommendation; and the word "may" to denote permission, neither a requirement nor a recommendation.

3.0 DESIGN, CONSTRUCTION, AND MODIFICATIONS

Eden provides requirements for establishing, managing, conducting, and assessing the program of controls over the design, construction, and modification of the Eden facility. This QAPD recognizes that described controls are integral to the management of the licensed activity and do not necessitate the establishment of a separate program. The QAP is established administratively by this QAPD and implemented by a series of implementing quality procedures, that are applicable to the specific sections of the QAPD and the scope of work activities.

3.1 Organization

Eden has established an organizational structure, functional responsibilities, levels of authority, and interfaces for establishing, executing, and verifying QAP implementation. The organizational structure includes internal and external functions for Eden, including interface responsibilities for multiple organizations that perform quality-related functions. Implementing documents assign more specific responsibilities and duties and define the organizational interfaces involved in

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conducting activities and duties within the scope of the QAP. Management considers the timing, extent, and effects of organizational structure changes. The Eden functional organization chart is provided in Exhibit B. Organization control measures, including a detailed organization chart, are provided in implementing procedures.

Eden's organization shall evolve during the design, construction, and operation of the facility. Organization changes made as the project evolves from construction to operation shall be provided in future revisions to this QAPD.

The organizational structure and assignment of responsibilities shall be defined and documented such that:

a) quality is achieved and maintained by those who have been assigned responsibility for performing work; and
b) quality achievement is verified by persons not directly performing the work.

Eden staff responsible for ensuring that appropriate controls have been established, and for verifying that activities have been correctly performed, will have sufficient authority, access to work areas, and freedom to:

a) identify problems;
b) initiate, recommend, or provide corrective action; and
c) ensure corrective action implementation.

All employees have the right and responsibility to stop work when they encounter an unsafe condition. Additionally, quality assurance and inspection personnel have the authority and the responsibility to stop work in process which is not being done in accordance with approved procedures or where safety-related SSCs quality may be jeopardized. This extends to off-site work performed by suppliers that furnish materials and services.

Independence shall be maintained between the organizations performing the work or service and oversight performed by the quality organization (i.e., quality assurance and quality control).

The Eden organizational structure includes the following:

Chief Executive Officer (CEO)

The CEO is responsible for the overall management and leadership of the company. The CEO is also responsible for all technical and administrative support activities provided by Eden and suppliers. The CEO provides direction to the Chief Operating Officer (COO) to fulfill the organization's responsibilities. The CEO reports to the Board of Directors. The CEO has overall responsibility for the Eden QAP and delegates the necessary responsibility and authority to direct reports to ensure

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quality is achieved and maintained by those who have been assigned the responsibility for performing the work and quality achievement is verified by persons not directly performing work.

Chief Operating Officer (COO)

The COO reports to the CEO and is responsible for all operational aspects of the company including safety, quality, environmental stewardship, regulatory affairs, security, facility management, information technology, supply chain management and all engineering support activities, including design engineering and construction. The COO is responsible for all external operations of Eden, including supplier organizations. The COO is responsible for integrating all quality requirements as defined in the QAP across the internal and external organizations and reports to the CEO on all matters concerning quality.

The COO delegates sufficient responsibility and authority to his direct reports to ensure that appropriate controls have been established and for verifying that activities have been correctly performed. Authority is also provided to access necessary work areas and encourages managers and employees to identify problems, initiate, recommend, or provide corrective action and ensure corrective action implementation.

Chief Technology Officer (CTO)

The CTO is the design authority for the facility and reports to the COO. The CTO has functional areas of responsibility that include authority for engineering support activities, design engineering, engineering configuration management, engineering administration, modifications and their implementation, facility design configuration control, facility engineering, system engineering, system testing, construction and technical support. The CTO may establish subordinate Engineering Director roles as needed and delegate duties and responsibilities among them as deemed necessary to execute the CTO functions. The responsibilities and authority of such directors shall be specified in implementing procedures under the Eden QAP.

Licensing Director

The Licensing Director reports to the COO and is responsible for all nuclear related licensing and is also responsible for maintaining the safety analysis. The Licensing Director is responsible for the planning and execution of the licensing process for the design, construction, and operation of the facility. The Licensing Director is responsible for ensuring clear lines of communication between Eden and the NRC.

Quality Assurance Director (QAD)

The QAD reports to the COO for day-to-day functions and to the CEO for any quality issues which cannot be resolved at the COO level. The QAD is responsible for the

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development and independent verification of implementation of the Eden QAP. Responsibilities include assuring compliance to regulatory requirements and procedures through independent assessments and technical reviews; monitoring organizational processes to ensure conformance to commitments and licensing document requirements; ensuring that suppliers implement quality assurance programs that meet the Eden QAP; and that procured items and services meet the applicable quality and technical requirements defined in the applicable procurement documents. The QAD has sufficient independence from other priorities to bring forward issues affecting safety, quality, and makes judgements regarding quality in all areas necessary regarding Eden's activities.

Procurement Director

The Procurement Director reports to the COO and is the primary point of contact between Eden and its suppliers. The Procurement Director is responsible for systematically planning and conducting procurement of items and services to conform with applicable quality and technical requirements. Responsibilities include soliciting and evaluating bids, supplier selection, preparation and approval of procurement documents that include appropriate acceptance criteria, receipt and acceptance of items and services, and supplier interface control.

Supplier organizations are responsible for their portion of the execution of the design, fabrication, procurement, construction, and testing of quality related SSCs for the facility as specified in Eden procurement documents. Such supplier organizations are responsible for identifying, implementing, and verifying flow-down of quality requirements as applicable. They participate in necessary assessments and inspections as specified in procurement documents.

Support Director

The Support Director reports to the COO and is responsible for planning and administering controlled documents and quality records. The Support Director prepares and implements procedures that provide for preparation, identification, approval, distribution, access, use, and revision of controlled documents and records, including their secure storage and retrieval.

Nuclear Engineering Director

The Nuclear Engineering Director reports to the CTO and is responsible for executing the Eden design control processes and procedures to establish the design, design criteria, design basis and functional and technical specifications for the Reactor and Hot Cell Facility SSCs. The Nuclear Engineering Director interfaces with the Licensing Director and Facility Engineering Director to ensure SSC designs incorporate applicable licensing and facility interface requirements.

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Facility Engineering Director

The Facility Engineering Director reports to the CTO and is responsible for all facility design and construction activities and is also responsible for establishing and maintaining the facilities configuration management system. The Facility Engineering Director is responsible for the planning and execution of the processes for the design, construction, and pre-operational testing of the facility.

3.2 Quality Assurance Program

As documented in this QAPD, Eden shall follow the requirements of ANSI/ANS-15.8-1995 (R2005;R2013) for establishing, implementing, and managing the QAP. The QAPD shall provide the requirements for establishing a QAP at the earliest time consistent with the project schedule for accomplishing quality-affecting activities. This shall include the managerial and administrative aspects of internal and external activities that affect quality of the Eden facility and programs.

The program shall provide for the appropriate and necessary indoctrination and training of personnel who perform activities that affect quality, to ensure that suitable proficiency is achieved and maintained.

3.3 Design Control

Eden shall prescribe, develop, document, and preserve the design of the SSCs of the Eden facility.

3.3.1 Design Requirements

Applicable design inputs, such as design bases, performance requirements, regulatory requirements, codes, and standards shall be identified and documented.

3.3.2 Design Process

Design interfaces shall be identified and controlled, and the design efforts shall be coordinated among the participating organizations. The applicability of standardized or previously proven designs, with respect to meeting pertinent design inputs, shall be verified for each application. Known problems affecting the standardized or previously proven designs, and their effects on other features, shall be considered. Deviations from the established and documented design inputs, including the reasons for the changes, shall be documented and controlled.

The final design shall:

a) be relatable to design input by documentation in sufficient detail to permit design traceability and verification; and

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b) identify assemblies and/or components that are part of the item being designed.

When a computer design program is used to develop portions of the facility design or to analyze a design for acceptability, that program shall be fully documented, validated, and controlled to ensure the correctness of its output. When a design program must be developed, the program shall be controlled to ensure that it is fully documented and validated. Where changes to previously valid computer programs are made, documented revalidation shall be required for the change. Verification of design-unique computer programs shall include appropriate benchmark testing.

3.3.3 Design Verification

Independent design reviews shall be used to verify the adequacy of design by one or more of the following:

a) the performance design reviews,
b) the use of alternate calculations,
c) the performance of qualification tests, or
d) comparison of similar proven systems.

The responsible design organization shall identify and document the particular design verification method or methods used. Design verification shall be performed by competent individuals or groups other than those who performed the design, but who may be from the same organization. In all cases the design verification shall be completed prior to reliance upon the SSCs, or computer program to perform its function in operations.

The need for or the use of qualification tests shall be defined in a formal test plan that shall include appropriate acceptance criteria and shall demonstrate the adequacy of performance under conditions that simulate the most adverse design conditions. Test results shall be documented and evaluated by the responsible design organization to assure that test requirements have been met.

3.3.4 Design Documents and Records

Design documents and records, which provide evidence that the design and design verification processes were performed, shall be collected, stored, and maintained for the life of the safety-related unit.

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3.3.5 Commercial Grade Items

The use of commercial grade equipment in safety-related applications shall be reviewed to assure that this equipment can adequately perform its intended function. When a commercial grade item, prior to its installation, is modified or selected by special inspection and/or testing to requirements that are more restrictive than the supplier's published product description, the component part shall be represented as different from the commercial grade item in a manner traceable to a documented definition of the difference.

3.3.6 Change Control

Modifications to facility SCCs, or computer codes shall be based on a defined "as-exists" design. Changes to verified designs shall be documented, justified, and subject to design control measures commensurate with those applied to the original design. These measures shall include assurance that the design analyses for the SSCs, or computer code are still valid. Where a significant design change is necessary because of an incorrect design, the design process and verification procedure should be reviewed and modified as necessary.

3.4 Procurement Document Control

Procurement documents shall contain sufficient technical and quality requirements to ensure that the items or services satisfy the needs of the procurement document or specification. The procurement documents at all procurement levels shall identify the documentation required to be submitted for information, review, or approval by the purchaser. At each level of a procurement, the procurement documents shall provide for access to the supplier's plant facilities and records, for inspection or audit by the purchaser, the designated representative, or other parties authorized by the purchaser. The procurement documents shall include purchaser's requirements for reporting and approving disposition of supplier nonconformances associated with the items or services being procured. The procurement documents for safety-related items should prohibit the supply of substandard or counterfeit parts and materials.

3.5 Procedures, Instructions, and Drawings

Activities affecting quality shall be performed in accordance with documented instructions, procedures, or drawings appropriate to the circumstances. These documents shall include or reference appropriate quantitative or qualitative

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acceptance criteria for determining that activities have been satisfactorily accomplished.

3.6 Document Control

The preparation, issue, and change of documents which specify requirements that affect quality, or prescribe activities affecting quality, shall be controlled to assure that correct documents are used. The document control system shall be documented, and provide for:

a) identification of documents to be controlled and their specified distribution;
b) identification of assignment of responsibility for preparing, reviewing, approving, and issuing documents; and
c) review of documents for adequacy, completeness, and correctness prior to approval and issuance.

Major changes to controlled documents shall be reviewed and approved by the same organizations that performed the original review and approval unless other organizations are specifically designated.

3.7 Control of Purchased Items and Services

The procurement of items and services shall be controlled to ensure appropriate procurement planning, source evaluation and selection, evaluation of objective evidence of quality furnished by the supplier, source inspection, audit, and examination of items or services for acceptance upon delivery or completion.

3.7.1 Supplier Selection

The selection of suppliers shall be based on evaluation of their capability to provide items or services in accordance with requirements of the procurement documents.

3.7.2 Work Control

Eden shall establish measures to control the supplier’s performance as appropriate.

3.7.3 Verification Activities

The supplier shall be responsible for the quality of its product and shall verify and provide evidence of that quality. Supplier-generated documents shall be controlled, handled, and approved in accordance with established methods. Means shall be implemented to provide for the acquisition, processing, and recorded evaluation of technical, inspection and test data against acceptance criteria. Based on complexity of the product and importance to safety, Eden shall consider independently

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verifying the quality of a supplier's product through source surveillances, inspections, audits, or review of the supplier's nonconformances, dispositions, waivers, and corrective actions.

3.7.4 Item or Service Acceptance

Eden shall establish a system to provide assurances that purchased items and services conform to procurement specifications. Eden's methods used to accept an item or related service from a supplier shall be a supplier Certificate of Conformance, source verification, receiving inspection, post-installation test, or a combination thereof. Receiving inspections shall be performed in accordance with established procedures and instructions, to verify by objective evidence such features as proper configuration, identification, and cleanliness, and to determine any shipping damage, fraud, or counterfeit.

3.8 Identification and Control of Items

When specified by codes, standards, or specifications that include specific identification or traceability requirements, the item identification and control process shall be capable of providing identification and traceability control. Items' identification shall be maintained from the initial receipt or fabrication of the items up to and including installation and use. Where physical identification on the item is either impractical or insufficient, physical separation, procedural control, or other appropriate means shall be employed. Identification markings shall be applied through the use of materials and methods which provide clear and legible identification and do not detrimentally affect the function or service life of the item. Markings shall be transferred to each part of an identified item when the item is subdivided, and shall not be obliterated or hidden by surface treatment or coatings unless substitute means are provided. Where specified, items having limited calendar or operating life shall be identified and controlled to preclude use of items whose shelf life or operating life has expired.

3.9 Control of Special Processes

Special processes include any in which the results are highly dependent on the control of the process or the skill of the personnel. These are also those processes in which the specified quality cannot be readily determined by inspection or non-destructive testing of the product. Special processes shall be controlled by instructions, procedures, drawings, checklists, travelers, or other appropriate means. It is the responsibility of the organization performing the special process to adhere to the approved procedures and processes. The requirements of applicable

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codes and standards, including acceptance criteria for the process, shall be specified or referenced in the procedures or instructions that control the process. Records shall be maintained as appropriate for the currently qualified personnel, processes, and equipment associated with special processes.

3.10 Inspections

Inspections to verify conformance of an item or activity to requirements shall be planned, documented, and performed. The inspection program shall apply to procurement, construction, modification, maintenance, and experiment fabrication. Inspection of items in-process or under construction shall be performed for work activities where product quality cannot be determined by inspection of the completed product. The final inspection shall be planned to arrive at a conclusion regarding conformance of the item to specified requirements. Completed items shall be inspected for completeness, markings, calibration, adjustments, protection from damage, or other characteristics as required to verify the quality and conformance of the item to specified requirements. Associated quality records shall be examined for adequacy and completeness. Only items that have passed the required inspections and tests shall be used, installed, or operated. Measuring and Test Equipment (M&TE) used to perform inspections shall be identified in inspection documentation for traceability of inspection results.

Inspection results shall be documented. Acceptance of items shall be documented and approved by authorized personnel. Inspection shall be performed by persons other than those who performed the work being inspected, but they may be from the same organization. Each person who verifies conformance of work activities for purposes of acceptance shall be qualified to perform the assigned inspection task. The need for formal training shall be determined, and training activities conducted as required to qualify personnel who perform inspections and tests. On-the-job training shall be included, with emphasis on firsthand experience gained through actual performance of inspections. Records of inspection personnel’s qualification shall be established and maintained by the Eden Support Director.

3.11 Test Control

Formal testing shall be required to verify conformance of designated SSCs to specified requirements, and demonstrate satisfactory performance for service, or to collect data in support of design or fabrication. Testing shall include prototype qualification tests, proof tests prior to installation, and functional tests. Test results shall be documented and evaluated by a responsible authority to assure that test requirements have been satisfied. Computer programs used for operational control

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shall be tested in accordance with an approved verification and validation plan, and shall demonstrate required performance over the range of operation of the controlled function or process.

3.12 Control of Measuring and Test Equipment

Tools, gauges, instruments and other M&TE used for activities affecting quality shall be controlled, and calibrated or adjusted, at specified periods to maintain accuracy within specified limits. Out-of-calibration devices shall be tagged or segregated, and not used until they have been recalibrated. Records shall be maintained of calibration data traceable to the individual piece of M&TE. Calibration and control measures are not required when normal commercial equipment provides adequate accuracy.

3.13 Handling, Storage, and Shipping

Handling, storage, and shipping of items shall be in accordance with work and inspection instructions, drawings, specifications, shipping instructions, or other pertinent documents or procedures for conducting the activity.

3.14 Inspection, Test, and Operating Status

The status of inspection and test activities shall be identified on the items or in documents traceable to the items, in order to assure that required inspections and tests are performed, and to assure that items which have not passed the required inspections and tests are not inadvertently installed or operated.

3.15 Control of Nonconforming Items and Services

Items that do not conform to requirements shall be controlled to prevent inadvertent installation or use. Controls on nonconforming items shall provide for identification, documentation, evaluation, segregation from like conforming items when practical, and disposition of nonconforming items. Nonconforming conditions shall be evaluated for further reporting to appropriate regulatory agencies. Nonconforming characteristics shall be reviewed, and recommended dispositions of nonconforming items proposed and approved, in accordance with documented procedures.

The disposition (use as-is, reject, repair, or rework) of nonconforming items shall be identified and documented. Technical justification for the acceptability of a nonconforming item dispositioned “repair” or “use as-is” shall be documented. Nonconformance to design requirements of items dispositioned “use as-is” or

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"repair" shall be subject to design control measures commensurate with those applied to the original design. The as-built records shall reflect the accepted deviation. Repaired or reworked items shall be reexamined in accordance with applicable procedures and with the original acceptance criteria, unless the nonconforming item disposition has established alternate acceptance criteria.

3.16 Corrective Actions

Conditions adverse to quality shall be identified promptly and corrected as soon as practical. The corrective actions shall be in accordance with the design requirements unless those requirements were faulty. In the case of a significant condition adverse to quality, the cause of the condition shall be investigated and corrective action taken to preclude recurrence.

3.17 Quality Records

A records system or systems shall be established at the earliest practicable time consistent with the schedule for accomplishing work activities. The records system or systems shall be defined, implemented, and enforced in accordance with written procedures, instructions, or other documentation. The records shall include as a minimum: inspection and test results, results of quality assurance reviews, quality assurance procedures, and engineering reviews and analyses in support of designs or changes and modifications.

Some records shall be maintained by or for Eden for the life of the particular item while it is installed in the plant or stored for future use. Such records shall be classified in accordance with the following criteria:

a) those which would be of value in demonstrating capability for safe operation;
b) those which would be of value in maintaining, reworking, repairing, replacing, or modifying an item;
c) those which would be of value in determining the cause or results of an accident or malfunction of a safety-related item;
d) those which provide required baseline data for in-service inspections; or
e) those which would be of value in planning for facility decommissioning.

Other records shall be retained for a shorter period as determined by Eden. The records shall be stored in a location or locations that prevent damage from moisture, temperature, and pestilence. Additional provisions shall be made for special processed records such as radiographs, photographs, negatives, microfilm,

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and magnetic media, to prevent damage from excessive light, stacking, electromagnetic fields, temperature, and humidity. Records maintained by a supplier shall be accessible to Eden.

3.18 Assessments

Eden shall conduct periodic assessments of quality-affecting activities during design, construction, or modification to evaluate the effectiveness of the as-implemented quality program. Assessments shall be performed in accordance with written procedures or checklists. Assessment results shall be documented, and should be reviewed by management personnel who have responsibility for the area assessed. Conditions requiring prompt corrective action shall be reported immediately to the appropriate management of the assessed organization.

Management of the assessed organization or activity shall investigate adverse findings, schedule corrective action (including measures to prevent recurrence), and notify the appropriate assessing organization in writing of action taken or planned. The adequacy of the responses shall be evaluated by the assessing organization. Assessment records include assessment plans, reports, written replies, and the record of completion of corrective action. Personnel selected for assessment assignments shall have experience or training commensurate with the scope, complexity, or special nature of the activities to be assessed. The assessor shall have the capability to communicate effectively, both in writing and orally.

3.19 Experimental Equipment

The QAP shall provide controls over the design, fabrication, installation, and modification of experimental equipment to the extent that these impact safety-related items.

4.0 FACILITY OPERATIONS

The regulations in 10 CFR 50.34(b) requires that each applicant for a license to operate a facility include, in its final safety analysis report, a description of the managerial and administrative controls to be used to assure safe operation. How Eden intends to comply with this requirement shall be described in the operating license submittal.

5.0 APPLICABILITY TO EXISTING FACILITIES

The Eden facility shall be a newly constructed facility and this section does not apply.

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6.0 DECOMMISSIONING

Quality assurance provisions in compliance with 10 CFR 50.82(b) shall be submitted as a part of the decommissioning plan submittal.

7.0 REFERENCES

7.1	ANSI/ANS 15.8-1995 (R2005;R2013)	1995, American National Standards Institute/American Nuclear Society, ANSI/ANS 15.8-1995, "Quality Assurance Program Requirements for Research Reactors".
7.2	ANSI/ANS 15.4-2016 (R2021	2016, American National Standards Institute/American Nuclear Society, ANSI/ANS 15.4-2016, "Selection and Training of Personnel for Research Reactors."
7.3	ANSI/ANS 15.1-2007 (R2018)	2007, American National Standards Institute/American Nuclear Society, ANSI/ANS 15.1-2007, "Development of Technical Specifications for Research Reactors".
7.6	NRC, NUREG 1537, 1996	1996, Nuclear Regulatory Commission, "NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content."
7.7	NRC, ISG NUREG-1537, 2012	2012, Nuclear Regulatory Commission, "Final Interim Staff Guidance Augmenting NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content."
7.8	NRC, RG 2.5, Rev. 1, 2010	2010, Regulatory Guide 2.5, Rev. 1, Nuclear Regulatory Commission, "Quality Assurance Program Requirements for Research and Test Reactors."

8.0 EXHIBITS

Exhibit A - Graded Approach to Quality

Exhibit B - Eden Functional Organizational Chart

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Exhibit A – Graded Approach to Quality

The graded approach to quality is a process by which the level of analysis, documentation, and actions necessary to comply with a requirement is commensurate with the safety significance. The graded approach permits the implementing organization to focus resources on those activities that are deemed, by qualitative analysis, to reduce the associated risks and hazards.

The activities and tasks are performed in accordance with approved implementing procedures.

QL-1 shall implement the full measure of this QAPD and shall be applied to safety-related SSCs, and safety-related activities.

QL-2 is applied to selected SSCs and activities intended to support or protect the safety-related activities.

QL-3 is applied to nonsafety-related SSCs and activities and does not support or protect the safety function of safety-related SSCs, or activities. However, the performance of QL-3 SSCs, and activities may be important to ensuring customer requirements are met, or operational or mission-related goals such as throughput, cost, or schedule are achieved. Controls, appropriate for the application, are applied to SSCs, and activities using elements of the Eden QAP for efficiency to avoid the creation and use of a separate or redundant management system. The controls on these SSCs and activities do not impact QL-1 or QL-2 SSCs and activities or the regulatory basis of the facility.

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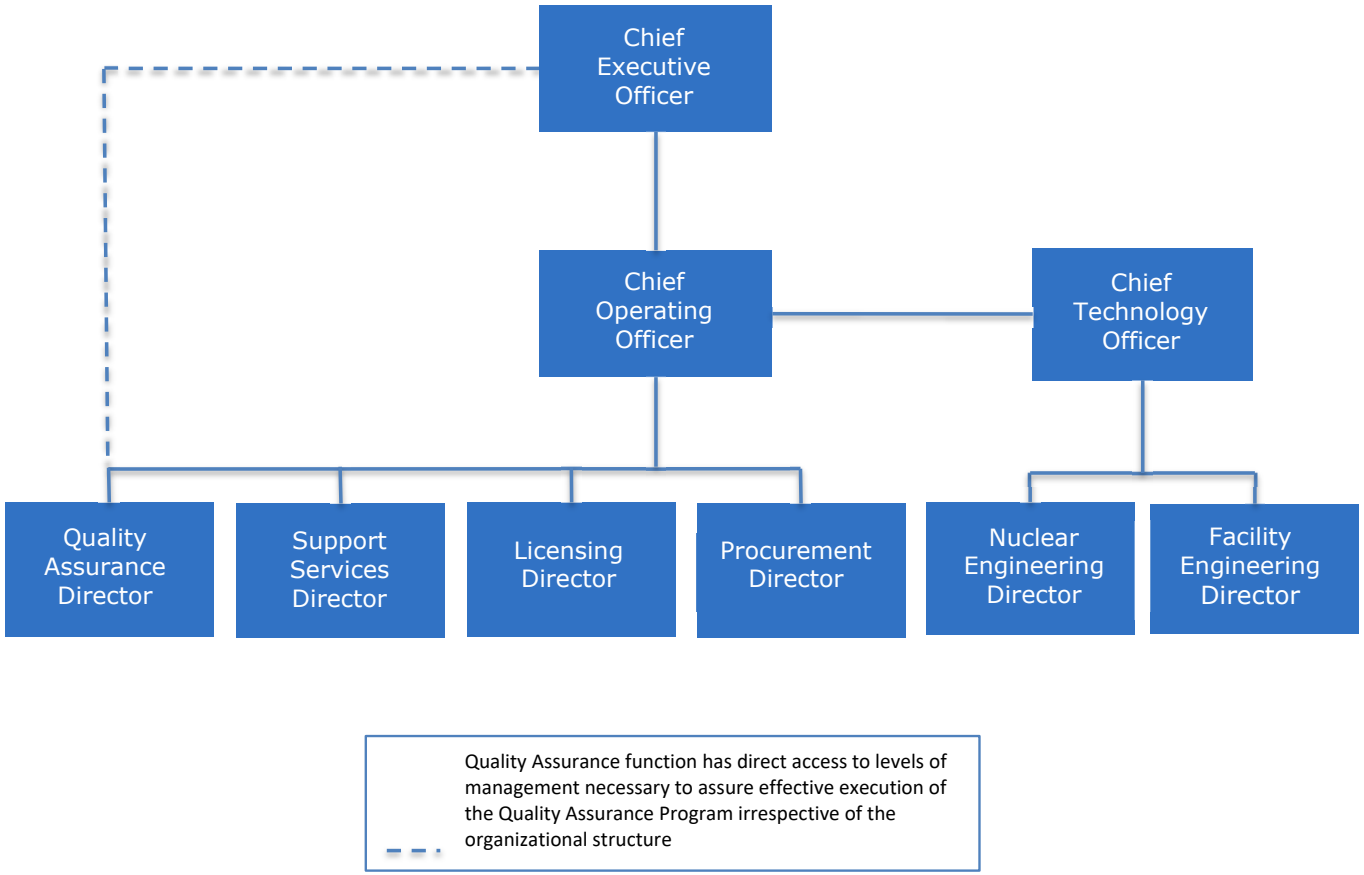
Exhibit B – Eden Functional Organization Chart



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Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 13
Accident Analyses

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Preliminary Safety Analysis Report

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CHAPTER 13a
REACTOR FACILITY ACCIDENT ANALYSES

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
$	dollar reactivity unit
°C	degrees Celsius
°F	degrees Fahrenheit
µm	micrometer
χ/Q	atmospheric dispersion coefficient
Al	aluminum
ALARA	As Low As Reasonably Achievable
Be	beryllium
BOP	balance of plant
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
CHF	critical heat flux
CHFR	critical heat flux ratio
Ci	curie(s)
CSDE	cloudshine effective dose equivalent
DCF	dose conversion factor
DF	dose factor
Eden	Eden Radioisotopes, LLC
EE	external event
EIPC	Eden Isotope Production Complex
EM	experiment malfunction
EMIF	Eden Medical Isotope Facility
ESF	engineered safety feature

Acronym/Abbreviation	Definition
FCCF	finite cloud correction factor
ft.	feet
gal.	gallon(s)
HCF	Hot Cell Facility
HEPA	high efficiency particulate air
hr.	hour(s)
I-131	iodine-131
I-133	iodine-133
I-135	iodine-135
IER	insertion of excess reactivity
km	kilometer(s)
Kr	krypton
Kr-87	krypton-87
Kr-88	krypton-88
kW	kilowatt(s)
kWt	kilowatt-thermal
L	liter(s)
LECS	liquid effluent control system
LEP	loss of normal electrical power
LEU	low-enriched uranium
LOC	loss of coolant
LOF	loss of coolant flow
m	meter(s)
m^3	cubic meter(s)
MAR	material at risk

Acronym/Abbreviation	Definition
MCNP	Monte Carlo n-particle
MHA	maximum hypothetical accident
mi.	mile(s)
mils	thousandths of an inch
min.	minute(s)
MME	mishandling or malfunction of equipment
MMT	mishandling or malfunction of targets
Mo-99	molybdenum-99
mrem	millirem
MRF	matrix release fraction
mWt	milliwatt thermal
MWt	megawatt thermal
Ni	nickel
PRF	pool release fraction
PRNI	power range nuclear instrument
PSAR	Preliminary Safety Analysis Report
rem	Roentgen equivalent man
RF	Reactor Facility
RPS	reactor protection system
RR	respiratory rate
RRF	room release fraction
s	second(s)
SSC	structure(s), system(s), and component(s)
ST	source term
$T_{1/2}$	half life

Acronym/Abbreviation	Definition
TEDE	total effective dose equivalent
TS	Technical Specification(s)
U	uranium
WRNI	wide range nuclear instrument
Xe	xenon
Xe-135	xenon-135
Xe-135m	xenon-135 metastable
Xe-138	xenon-138

13a. Reactor Facility Accident Analyses

The purpose of this chapter is to provide a preliminary analysis of the hazards potentially affecting the Eden Radioisotopes, LLC (Eden) all-target non-power reactor. This chapter presents an analysis of the bounding postulated accidents at the Reactor Facility (RF) portion of the Eden Medical Isotope Facility (EMIF).

This accident analysis applies only to the accidents that could occur at the RF. It does not cover accidents related to other operations at the EMIF, including irradiated target processing and target fabrication. The accidents that are analyzed in this chapter were identified using the following sources of information:

- NUREG-1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content (Part 1 and 2).
- Final Interim Staff Guidance Augmenting NUREG-1537, Parts 1 and 2, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content, for Licensing Radioisotope Production Facilities and Aqueous Homogenous Reactors.
- Current preliminary design for the RF and associated processes.
- Experience of the hazard analysis team.

This chapter considers the most likely postulated events that may occur due to operations at the RF, analyzes the potential radiological consequences to the public, the worker, and the environment, estimates the likelihood of the events occurring, and identifies and assesses associated preventive and mitigative features to ensure that the potential radiological consequences are acceptable.

The level of analysis performed to characterize the hazards associated with the RF is consistent with the complexity, hazard potential, and life-cycle stage of the facility. Quantitative analysis is conducted to augment and reinforce the qualitatively assigned consequence estimates of bounding and postulated accident scenarios. Those events with greater potential unmitigated consequences, a higher frequency of occurrence, unusual event dynamics, protective features unique to the event, or requirements for further consideration by NUREG-1537 were selected for further evaluation in this chapter.

NUREG-1537 provides guidance for the Preliminary Safety Analysis Report (PSAR) format and content as well as a standard review plan. The postulated event category of accidents specified in NUREG-1537 are as follows:

- Maximum hypothetical accident (MHA).
- Insertion of excess reactivity.
- Loss of coolant.
- Loss of coolant flow.
- Mishandling or malfunction of fuel.
- Experiment malfunction.
- Loss of normal electrical power.

- External events.
- Mishandling or malfunction of equipment.

13a.1 ACCIDENT-INITIATING EVENTS AND SCENARIOS

Table 13a.1-1 presents the accidents analyzed and their analysis location in the chapter. These accidents represent bounding conditions and may envelop several other different accident conditions. For each accident identified, an accident scenario is developed that could act as the initiator or multiple initiators for the accident. In the accident scenario development, preventative and mitigative features and conditions are identified and analyzed that would prevent or mitigate the accident progression and the release of radioactive material from the RF high bay.

No accident initiating events in the RF have been identified that could affect the operations in the Hot Cell Facility (HCF) or cause a separate initiating event to occur in the HCF.

13a.1.1 MAXIMUM HYPOTHETICAL ACCIDENT

The MHA is a limiting fission product release event that is not expected to occur and for which the scenario may not be entirely credible, consistent with guidance in NUREG-1537. The initiating event and the scenario details need not be analyzed, but the potential consequences should be analyzed and evaluated. The MHA selected should bound all credible potential fission product release accidents at the facility yet should be an event that is not likely to occur during the life of the facility.

MHA – Overheating of a target during reactor operation

The MHA analyzed is a target that becomes overheated due to the fuel/cladding interface delamination. Although this event is credible at some level, a catastrophic failure of the target, that is, complete delamination of the low-enriched uranium (LEU) foil and cladding, is not credible. The MHA evaluated is a complete melting of the uranium (U) foil in a peak target that has been irradiated at full power for 25 days. The assumption is that the complete U foil separates from both sides of the cladding, loses its cooling capability, melts, breaches the cladding, and the complete target fission product and actinide inventory is released in the pool.

13a.1.2 INSERTION OF EXCESS REACTIVITY

Accidents involving the insertion of excess reactivity are bounded by IER-1, Inadvertent control rod bank withdrawal and IER-2, Prompt insertion of excess reactivity from activation canister ejection. The design and operation of the reactor core preclude other methods for rapid insertion of positive reactivity such as by control rod, safety rod, or target insertion.

IER-1 – Inadvertent control rod bank withdrawal

The control rod bank (four control rods operated together in parallel) is continuously withdrawn inadvertently, resulting in a power increase and possible overheating of the targets if unmitigated by a scram. The insertion of reactivity inadvertently by the operator or by mechanical failure is considered a not-unlikely event.

IER-2 – Prompt insertion of excess reactivity from activation canister ejection

A negative worth activation/irradiation canister (located in an irradiation location in the reactor core) is rapidly removed from the reactor core with the reactor at full power, resulting in a power increase and possible overheating of the targets. The insertion of reactivity inadvertently by mechanical failure is considered an unlikely event.

13a.1.3 LOSS OF COOLANT

LOC-1 – Partial loss of coolant

The reactor pool water level decreases, either due to a leak or break in the primary side of the coolant heat rejection system, a leak or break in the primary coolant cleanup system, or operator error inadvertently removing water from the pool. With the reactor at full operating power, the pool water heats up, allowing for the potential overheating of the targets. A partial loss of coolant from the pool by operator error or mechanical failure is considered a not-unlikely event.

13a.1.4 LOSS OF COOLANT FLOW

LOF-1 – Loss of cooling system flow

LOF-2 – Loss of cooling system heat sink

A loss of functionality in the coolant heat rejection system (LOF-2), or loss of flow of the primary coolant pump (LOF-1) with the reactor at full power causes the pool water to heat up, leading to potential overheating of the targets. The loss of cooling system heat sink and loss of cooling system flow are considered not-unlikely events.

LOF-3 – Overheating of a target due to flow blockage

A loss of flow through the core due to a partial or complete blockage of the flow paths in the lower grid plate with the reactor at full power causes the core water to heat up and the potential for overheating of the targets. The partial loss of water flow through the core is considered a not-unlikely event.

13a.1.5 MISHANDLING OR MALFUNCTION OF FUEL

MMT-1 – Dropped/mishandled irradiated targets

MMT-2 – Mishandled irradiated target transfer basket

One or several irradiated targets are dropped in the pool during transfer (MMT-1) or the irradiated target transfer basket holding irradiated targets falls over, dumping the irradiated targets into the pool (MMT-2). The targets could be breached as a result of hitting the pool floor or other objects. A dropped or mishandled irradiated target or transfer basket is considered a not-unlikely event.

13a.1.6 EXPERIMENT MALFUNCTION

EM-1 – Failure of activation/irradiation canister

An activation/irradiation canister ruptures while being irradiated, resulting in the release of activation products into the reactor pool. This could be due to canister failure or melting of the activation material due to overheating. The rupture of a canister could damage nearby targets. Failure of an activation/irradiation canister is considered a not-unlikely event.

13a.1.7 LOSS OF NORMAL ELECTRICAL POWER

LEP-1 – Loss of normal electrical power

A partial or full loss of electrical power to the RF high bay and associated coolant heat rejection system, ventilation system, and auxiliary systems causes a partial or full shutdown of some or all of these systems. Partial or full loss of electrical power to the reactor control room causes a partial or full loss of monitoring capability of the reactor. Partial or full loss of normal electrical power to the RF is considered a not-unlikely event.

13a.1.8 EXTERNAL EVENTS

EE – Postulated external events

Postulated accidents within the external events category have been identified as follows:

- Earthquake.
- Tornado or high winds.
- Precipitation.
- External flood.
- Off-site stationary and transportation accidents.

13a.1.9 MISHANDLING OR MALFUNCTION OF EQUIPMENT

MME-1 – Heavy load drop on reactor core

A heavy load is dropped onto the reactor core resulting in damage to the targets. A heavy load dropped on the reactor core is considered a not-unlikely event.

Table 13a.1-1
Accidents Analyzed

Accident Category	Accident	PSAR Section
Maximum hypothetical accident	MHA – Overheating of a target during reactor operation	13a.1.1 13a.2.3.1
Insertion of excess reactivity	IER-1 – Inadvertent control rod bank withdrawal IER-2 – Prompt insertion of excess reactivity from activation canister ejection	13a.1.2 13a.2.3.2
Loss of coolant	LOC-1 – Partial loss of coolant	13a.1.3 13a.2.3.3
Loss of coolant flow	LOF-1 – Loss of cooling system flow LOF-2 – Loss of cooling system heat sink LOF-3 – Overheating of a target due to flow blockage	13a.1.4 13a.2.3.4
Mishandling or malfunction of targets	MMT-1 – Dropped/mishandled irradiated targets MMT-2 – Mishandled irradiated target transfer basket	13a.1.5 13a.2.3.5
Experiment malfunction	EM-1 – Failure of activation/irradiation canister	13a.1.6 13a.2.3.6
Loss of normal electrical power	LEP-1 – Loss of normal electrical power	13a.1.7 13a.2.3.7
External events	EE – Postulated external events	13a.1.8 13a.2.3.8
Mishandling or malfunction of equipment	MME-1 – Heavy load drop on reactor core	13a.1.9 13a.2.3.9

Abbreviations: PSAR = Preliminary Safety Analysis Report

13a.2 ACCIDENT ANALYSIS AND DETERMINATION OF CONSEQUENCES

The accident dose criterion adopted by Eden for radiation dose to an individual member of the public is 1.0 rem, total effective dose equivalent (TEDE) to the whole body. This is applied at the 500-meter (m) (1640-foot [ft.]) site boundary or, alternatively, at the maximum dose exposure distance from the facility for a member of the public. For the occupational worker, the TEDE dose limit is 5 rem, or 50 rem committed dose equivalent to any individual organ or tissue other than the lens of the eye. These dose limits are established by Title 10 of Code of Federal Regulations (10 CFR) 50.34(a)(1)(i); 10 CFR 20.1301; and 10 CFR 20.1201.

The calculated mitigated dose to an individual member of the public at the 500-m (1640-ft.) site boundary, or the maximum exposure distance, for the MHA or any other postulated accident must be less than 1.0 rem (TEDE) to be within the accident dose criterion. If the dose is found to be greater than this value, additional controls, safety-related structures, systems, and components (SSCs), or engineered safety features (ESFs) must be incorporated into the facility design bases. Even if calculations show that safety-related SSCs, ESFs, or both are not needed to maintain public doses within the accident dose criterion, the design may incorporate additional SSCs to provide defense-in-depth and maintain accident doses As Low As Reasonably Achievable (ALARA). The TEDE includes the dose due to both immersion and inhalation. Ingestion is not included because there are no crops, farms, dairies, or watersheds near the site boundary. The immersion dose includes direct exposure to the individual as the radioactive cloud, or plume, immerses and passes by the individual. The inhalation dose includes the dose from radioisotopes inhaled from the cloud as it passes by the individual. The inhalation dose includes direct exposure from the material while in the lungs and the 50-year committed dose from material remaining in the lungs or passing into the body organs.

The calculated dose to an occupational worker includes the direct exposure and committed inhalation dose to a worker within the RF high bay during the accident and release of radionuclides into the reactor pool and/or high bay. It is assumed that the occupational worker responds to radiation alarms in the RF high bay and exits the area within a defined time period.

The cumulative airborne releases of radionuclides to the environment were developed from single isotope release calculations from the release point under evaluation. The downwind dose estimates were developed using standard Gaussian-plume dispersion models (Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessment at Nuclear Power Plants, Revision 1) for air transport and derivation χ/Q (atmospheric dispersion coefficient) values (see Subsection 2.3.4), ORIGEN-2.2 Isotope Generation and Depletion Code (Croff, 1980), and immersion and inhalation dose conversion factors (DCFs) (USEPA, 1988; USEPA, 1993). Combining doses for the individual isotopes released at the distance of interest provides the TEDE estimate for a member of the public.

The downwind dose calculations use a simple conservative approach. An F stability, 1 m per second (s) (3.3 ft/s) wind speed was chosen for the analysis, which represents a conservative bound on the downwind dose. A ground release and an RF stack height of 15 m (49.2 ft.) were used in the analysis. No building wake effects, exhaust velocity, or surface roughness effects are used in the analysis. The results of the analysis are presented in the following subsections in more detail.

13a.2.1 SOURCE TERM EVALUATION

The quantity of airborne radionuclides that leave the RF high bay in the event of a postulated accident is referred to as the source term (ST). The ST quantity is specific to a given accident. For a given postulated accident in the reactor pool, the ST for each radionuclide is as follows:

$$ST_i = MAR_i \times MRF_i \times PRF_i \times RRF_i \quad \text{(Equation 13a.2-1)}$$

where:

ST_i is the ST for the specific radionuclide *i* leaving the RF, in units of activity

MAR_i is the material at risk (MAR) for the radionuclide *i*, in units of activity

MRF_i is the matrix release fraction (MRF) for the radionuclide *i*

PRF_i is the pool release fraction (PRF) for the radionuclide *i*

RRF_i is the room release fraction (RRF) for the radionuclide *i*

The ST is calculated for each radionuclide, the sum of which makes up the total ST inventory. The sum of the ST_i values represents the total amount of radionuclide activity released from the RF to the environment through the release pathway under consideration. For accidents involving the targets, the fission product radionuclide inventory and actinide inventory make up the total MAR. For accidents involving activation isotopes, the MAR is addressed on a case-by-case basis. Activation products may also exist in the target cladding materials, but this inventory, and its ultimate contribution to the downwind dose, is very small and is ignored.

Monte Carlo n-particle (MCNP) burnup calculations, ORIGEN-2.2 calculations, and calculations using fission product yields are used to determine the radionuclide inventory in the target fuel as a function of the target power and the irradiation duration. Agreement is found between these methods for most of the fission product radionuclides. Differences occur when calculating the inventory for fission products with large neutron absorption cross sections, such as xenon-135 (Xe-135), or for actinides that are dependent on the neutron flux energy spectrum in the reactor. For these isotopes, the MCNP burnup calculations are used because the neutron energy spectrum is incorporated into the calculated results.

13a.2.1.1 Matrix Release Fraction

For a target, the U metal foil and the aluminum (Al) cladding are the two primary barriers that prevent the release of fission products into the pool. During normal, full-power operations, the effectiveness of the barriers in retaining the fission products is assumed to be 100 percent. Under postulated accident conditions, these two barriers could be challenged, allowing fission products and actinides to be released into the pool water. The MRF for a specific radionuclide is defined as the fraction of the inventory that is released from a target into the pool water following a postulated accident. For the targets, three types of accident conditions could potentially jeopardize the integrity of the barriers:

- Target cladding failure due to excessive heat flux.
- U foil melting due to delamination of the foil from the cladding.
- Target cladding breach due to dropping or a load falling on the targets.

As discussed in Chapter 4a, because the range of a fission fragment in U metal is small, on the order of 7 micrometers (μm) (0.28 thousandths of an inch [mils]), and the thickness of the U metal foil is on the order of [[ ]]$^{PROP/ECI/SRI}$, most of the fission products are directly deposited within the U metal foil matrix. A nickel (Ni) barrier coating, approximately [[ ]]$^{PROP/ECI/SRI}$ in thickness, is plated on both sides of the U metal foil. Any fission products escaping the surface of the U foil during a fission event are deposited in the Ni coating.

By design there are no interface gaps between the U foil and the cladding, as described in Chapter 4a and 4b. There is a small axial gap formed during the hydroforming process, as described in Subsection 4b.4.2, where noble gases can accumulate. There is not enough burnup on the targets to allow for a significant noble gas generation and release from the U foil matrix. Several references can be used to determine the appropriate release fraction in the fuel/cladding interface gap for noble gases, halogens, and other chemical groups. Work performed at Argonne National Laboratory and Missouri University Research Reactor (Vandegrift, 2016; Solbrekken et al., 2014) as part of the Global Threat Reduction Initiative program is used in this chapter to estimate the interface gap release fraction. From this experimental work, a release fraction of 4E-4 is appropriate for a contact foil interface gap release for the noble gases.

- For accidents that result in a breach of the target cladding where fuel melting does not occur, the MRF for the noble gases is assumed to be 4E-4.
- For accidents that result in a breach of the target cladding where fuel melting occurs, the MRF for the noble gases, halogens, and all other chemical groups is assumed to be 1.0.
- For accidents where the target cladding is breached because of dropping or a load falling on targets, the MRF for the noble gases is assumed to be 4E-4.

13a.2.1.2 Pool Release Fraction

For fission product release accidents that occur in the pool, the pool water captures a significant fraction of the radionuclides released from the target. Restrepo surveyed experimental and theoretical work to determine the most appropriate decontamination factors for a subcooled pool several meters in depth (Restrepo, 1992). The PRF is the inverse of the decontamination factor. The conclusion is that decontamination factors of 1 (PRF = 1.0) for the noble gases, 100 (PRF = 0.01) for the halogens, and 1400 (PRF = 0.00071) for all other chemical groups represent conservative bounds.

Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, Revision 0, Appendix B-1, recommends decontamination factors for spent fuel pools. The decontamination factor recommended for noble gases is 1 (PRF = 1.0) and an overall effective decontamination factor of 200 (PRF = 0.005) for iodine. Regulatory Guide 1.183, Revision 1, Appendix B-2, presents a more in-depth methodology for determining the iodine decontamination factor based on a function of bubble size and rise time. The result from Regulatory Guide 1.183, Revision 0, is more conservative than Regulatory Guide 1.183, Revision 1, and is used as the PRF for the halogens.

Based on the reviewed literature, the PRFs selected for accident analysis are based on those suggested by Regulatory Guide 1.183, Revision 0, Appendix B-1, for the noble gases and halogens, and Restrepo for all other chemical groups (Restrepo, 1992). Based on the reviewed literature, the PRFs selected for accident analysis are based on those suggested by Regulatory Guide 1.183, Revision 0, Appendix B-1, for the noble gases and halogens, and Restrepo for all other chemical groups (Restrepo, 1992). The PRF values used are shown in Table 13a.2-1.

13a.2.1.3 Room Release Fraction

The radionuclides released from the pool into the RF high bay are released into the environment through the 15-m (49-ft.) RF high bay exhaust stack with no additional filtering by the stack ventilation system. Although the RF high bay ventilation system includes high efficiency particulate air (HEPA) and charcoal filters for defense-in-depth, no credit is taken in the accident analysis for radionuclide filtering from the RF high bay to the environment.

To include a worst-case scenario in the accident analysis, a ground release with no filtering is also presented to show that the RF high bay ventilation system is not required as an ESF.

The release rate from the high bay environment is not considered to be instantaneous. This assumption has no significant effect on the ST for radionuclides with half-lives ($T_{1/2}$) on the order of 1 hour (hr.) or greater. Noble gas and halogen radionuclides that are significantly affected by factoring in the high-bay release rate include xenon-135 metastable (Xe-135m) ($T_{1/2}$=15.3 minutes [min.]), xenon-138 (Xe-138) ($T_{1/2}$=14.1 min.), bromine-84 ($T_{1/2}$=31.8 min.), and other short-lived radionuclides.

The RRF for radionuclide *i*, is calculated using the following formula:

$$RRF_i = \frac{1}{\frac{\lambda_i}{\dot{m}/V} + 1} \qquad \text{(Equation 13a.2-2)}$$

where:

RRF_i is the RRF for the radionuclide *i*

λ_i is the decay constant for the radionuclide *i* ($\ln 2/T_{1/2}$) in units of s^{-1}

$\dot{m}/V$ is the room exhaust exchange rate in units of s^{-1}

Assuming the RF high bay exchange rate is six room exchanges per hour (for both stack release and ground release), the result for $\dot{m}/V$ is 0.00167 s^{-1}. For a radionuclide with a half-life of 15 min., the RRF is 0.68.

13a.2.2 DOSE CALCULATIONS

Dose calculations to members of the public and occupational workers for an accident involving the airborne release of radioactive materials are performed by using the radionuclide ST and dose factors (DF) for the specific radionuclide. The TEDE is the effective whole-body dose to a member of the public or occupational worker in the RF high bay. The TEDE is derived by multiplying the ST by the DF and includes dose exposure from both immersion and inhalation. Values for the inhalation effective DCF (coefficient), committed effective dose equivalent

(CEDE), and the immersion effective DCF (coefficient), cloudshine effective dose equivalent (CSDE), can be used from a number of sources. For this analysis, Federal Guidance Report No. 11 (USEPA, 1988) is used for the inhalation effective dose coefficients and Federal Guidance Report No. 12 (USEPA, 1993) is used for the immersion effective dose coefficients.

For this analysis, the TEDE includes the dose due to immersion and inhalation. Ingestion is not included because there are no crops, farms, dairies, or watersheds within the area of the site boundary. The immersion dose includes direct exposure to the individual as the radioactive cloud, or plume, immerses and passes by the individual. The inhalation dose includes the dose from radioisotopes inhaled from the cloud as it passes by the individual. The inhalation dose includes direct exposure from the material while in the lung and the 50-year committed dose from material remaining in the lung or passing into the body organs. The TEDE is formulated as follows:

$$TEDE = \sum_{i=1}^{n} TEDE_i \qquad \text{(Equation 13a.2-3)}$$

$$TEDE_i = ST_i \times DF_i \qquad \text{(Equation 13a.2-4)}$$

$$DF_i = (CEDE_i \times RR + CSDE_i \times FCCF) \times \frac{\chi}{Q} \qquad \text{(Equation 13a.2-5)}$$

where:

$TEDE_i$ is the TEDE for the radionuclide *i*, in units of total dose (rem)

ST_i is the ST for the radionuclide i leaving the stack, in units of activity (curies [Ci])

DF_i is the DF for the radionuclide *i*, in units of total dose per activity (rem/Ci)

χ/Q is a function of the distance from the stack, stack height, weather stability class, and wind speed, in units of seconds per cubic meter (s/m^3)

$CEDE_i$ is the CEDE coefficient; the inhalation dose to the member of the public from the radionuclide *i* as the plume passes by the person and they inhale the material in the plume—the DF includes direct exposure from the radionuclide while in the lungs and the 50-year committed dose from isotope remaining in the lungs or passing into the body organs, in units of rem/Ci

RR is the breathing rate, 3.3E-4 m^3/s

$CSDE_i$ is the CSDE coefficient; the external direct exposure dose to the member of the public from radionuclide *i* as the plume passes by the person and they are exposed to the beta and gamma rays emitted from the radionuclide, in units of rem-m^3/Ci-s

FCCF is the Finite Cloud Correction Factor (FCCF), that is a function of the distance from the stack and the weather stability class

Table 13a.2-2 presents the results for χ/Q in units of s/m^3 and the FCCF as a function of distance from the RF high bay exhaust stack or RF high bay ground release. The values are for

a stack height of 15 m (49 ft) or a ground release, a 1 m/s (3.3 ft/s wind speed, and an F stability weather class. The results show that the dose to the maximum exposed individual member of the public occurs at 600 m (1969 ft.) (100 m [328 ft.] beyond the site boundary) with a χ/Q value of 0.000407 s/m^3 for a stack release at 600 m (1969 ft.) or 0.00191 s/m^3 for a ground release at 500 m (1640 ft.).

For the downwind dose calculations in this analysis, it is assumed that a member of the public is either at a distance of 600 m (1969 ft.) from the 15-m (49-ft.) RF high bay exhaust stack, representing the peak value for χ/Q, or at a distance of 500 m (1640 ft.) for a ground release for the duration of the accident release. For comparison, a ground release at 500 m (1640 ft.) results in a χ/Q value 4.7 times larger than the value for the 15 m-stack at 600 m (1969 ft.).

The nearest residence is in Eunice, New Mexico, 1.7 miles (mi.) (2740 m) west-northwest from the RF. Table 13a.2-2 shows that the χ/Q value calculated at 2500 m (1.6 mi.) is 0.000135 s/m^3 for a stack release or 0.000169 s/m^3 for a ground release, assuming that the wind is blowing in a west-northwest direction from the RF. The prevailing wind direction at the Eden Isotope Production Complex (EIPC) site is from the south.

The TEDE value for each radionuclide was calculated using the ST and the DF formulas. In addition, a radionuclide decay time of 800 s (13.3 min.) was used to account for transit time from the exhaust stack or building ground release point to the receptor. The TEDE values were calculated on a per kilowatt thermal (kWt) basis. The following factors were used to generate the TEDE values:

MRF = 1.0 for all radionuclides, can be modified for specific accidents with cladding breach or fuel melt

PRF = 1.0 for noble gases, 0.005 for halogens, 0.00071 all other chemical groups

$$RRF_i = \frac{1}{\frac{\lambda_i}{0.00167\ s^{-1}} + 1} \qquad \text{(Equation 13a.2-6)}$$

χ/Q (stack release at 600 m [1969 ft.]) = 0.000407 s/m^3 for F stability, 1 m/s wind speed

FCCF (600 m) = 0.111

χ/Q (ground release at 500 m [1640 ft.]) = 0.00191 s/m^3 for F stability, 1 m/s wind speed

FCCF (500 m) = 0.096

χ/Q (stack release at 2500 m [1.6 mi.]) = 0.000135 s/m^3 for F stability, 1 m/s wind speed

χ/Q (ground release at 2500 m [1.6 mi.]) = 0.000169 s/m^3 for F stability, 1 m/s wind speed

FCCF (2500 m [1.6 mi.]) = 0.307

RR = 3.3E-4 m^3/s

$CEDE_i$ = Federal Guidance Report No. 12, Table 2.1, Effective Committed Dose for Inhalation

$CSDE_i$ = Federal Guidance Report No. 11, Table III.1, Effective Dose for Air Submersion

The results for the TEDE for each radionuclide are summed for the chemical group types. Table 13a.2-3 shows the TEDE sum for each group and the fraction of the dose contributed by each

group. The noble gases and halogens contribute 78 percent of the total dose, assuming all the radioisotopes generated in the fuel are released into the pool (MRF=1.0 for all radionuclides). The total downwind dose for a 25-day target irradiation is 2.01E-3 rem/kWt for a stack release, and 8.88E-3 rem/kWt for a ground release.

The main radionuclides contributing to the downwind dose (for noble gases and halogens) are identified. The radionuclides, their half-lives, and their percentage contribution to the total noble gas and halogen downwind dose for a 25-day irradiation are as follows:

Noble Gases

Krypton-87 (Kr-87) (1.27 hr.) = 7.7 percent

Krypton-88 (Kr-88) (2.84 hr.) = 29.9 percent

Xe-135 (9.10 hr.) = 1.6 percent

Xe-138 (14.1 min.) = 11.2 percent

Halogens

Iodine-131 (I-131) (8.04 days) = 29.3 percent

Iodine-133 (I-133) (20.8 hr.) = 14.1 percent

Iodine-135 (I-135) (6.57 hr.) = 2.9 percent

All other noble gases and halogens contribute less than 3.3 percent combined to the total noble gas and halogen downwind dose. Of these, the most important noble gas radionuclide is Kr-88, followed by Kr-87 and Xe-138. Although the contribution from Xe-138 is relatively large, its half life is short (14.1 min.). Hence any pool retention for even a short period of time reduces the Xe-138 contribution to downwind dose. The most important halogen radionuclide is I-131, followed by I-133 and, to a lesser extent, I-135. No bromine isotopes contribute significantly to the downwind dose.

For the other fission products, cerium-144, yttrium-91, and tellurium-132 are the most important radionuclides, contributing 23.7 percent, 14.2 percent, and 7.7 percent, respectively, to the total other fission products downwind dose. Neptunium-239 dominates the actinide downwind dose, contributing 37.4 percent.

For the occupational worker dose during an accident, it is assumed that the worker is in the RF high bay when the accident occurs. The worker dose is estimated using the same basic formulas as presented for the member of the public dose. The radionuclides leaving the pool are assumed to be uniformly distributed in the high-bay volume, and the worker is assumed to exit the high bay when radiation alarms sound.

Assuming a room volume of 4000 m^3 (141,259 cubic feet [$ft.^3$]) and an exit time of 1 min., the TEDE worker dose is calculated to be 2.4E-2 rem/kWt for the noble gases and 2.5E-2 rem/kWt for the halogens. The worker thyroid dose is calculated to be 0.83 rem/kWt.

13a.2.3 ACCIDENT EVALUATION

The accidents presented in Subsection 13a.1.1 are evaluated with respect to their initial conditions, initiating events, scenario development, radioactive material ST, and downwind and worker dose estimates.

13a.2.3.1 Maximum Hypothetical Accident

The MHA analyzed is a target that becomes overheated due to fuel/cladding interface delamination.

MHA – Overheating of a target during reactor operation

A catastrophic failure of a target by melting the complete LEU fuel foil is not credible. Melting of the complete foil is only possible if delamination of the LEU foil from the cladding and subsequent melting of the foil occurred. The MHA evaluated assumes a complete melting of the U foil in a peak target location that has been irradiated at full power for 25 days. The assumption is that the complete U foil separates from both sides of the cladding, loses its cooling capability, melts, breaches the cladding, and is dispersed in the pool with the complete target fission product and actinide inventory.

Scenario Development

Target fabrication is described in Subsection 4a.2.1. Rigorous fabrication procedures and quality inspections ensure that every target irradiated meets the same quality requirements for the designed form, fit, and function. The most important factor in the fabrication of the target that allows for heat transfer to the coolant is that contact is maintained between the U foil, the thin Ni barrier, and both sides of the Al cladding.

A manufacturing defect or an improper fabrication fault could potentially cause a small area of the target to have a gap between the U foil and the cladding. However, if the U foil is in contact with the cladding on even one side of the U foil, that contact is sufficient to adequately cool the exposed U foil area without failure of the target. If a failure in a target did occur due to insufficient contact of the U foil with both sides of the cladding, it would most likely occur when the target was fresh with no irradiation history. That is, it is expected that a defective target would fail during its first full power operation. For this condition, because the target has not experienced any significant burnup, the fission product inventory and subsequent release into the pool is small and possibly even negligible.

A failure could potentially occur on a defective target after undergoing several thermal cycles from zero power to full power. In this case, it is assumed that the noble gas and halogen fission products are at their saturated activities when failure occurs. Again, it is expected that there could be localized overheating in a small area of the target, with a limited release of the radionuclide inventory.

A gap could occur between the U foil and the cladding if the noble gases generated during irradiation were able to coalesce and migrate to the surface of the foil. This is not expected because the U foil peak temperature is low (approximately 150 degrees Celsius [°C] or 302 degrees Fahrenheit [°F]) at full power, and the ratio of noble gas atoms created per U atom is small. If the noble gas atoms did escape the U foil, they could pressurize the cladding and form a gap. For krypton (Kr) about 3.8 percent and for xenon (Xe) about 21.7 percent of the fission events result in a stable or long-lived noble gas nuclide. For a 30 kWt 25-day irradiation, 0.00013 moles of Kr and 0.00075 moles of Xe gas are created.

Assuming that all the noble gases are hypothetically released from the U foil and form a gap on both sides of the foil, a gap of 0.20 mils (5.1 μm) to 0.25 mils (6.4 μm) is created due to the Kr and Xe gas pressure on the cladding. The calculation was performed using a Young’s modulus

of 10,000 thousand pounds per square inch (68,950 megapascal). A gap of 0.25 mils (6.4 μm) filled with Xe gas allows for the U foil temperature to remain well below the U metal melting point (1130°C [2066°F]). The peak U temperature is about 456°C (853°F).

There is no credible scenario that allows for the complete target U foil to melt due to a catastrophic delamination of the foil from the cladding. Hence, this postulated accident represents a bounding event. Other than rigorous quality processes, procedures, and inspections, there are no Technical Specification (TS) considerations that could be imposed that would prevent or mitigate the event from occurring.

The MHA scenario assumes the complete U foil melts due to complete delamination of the target foil from the Al cladding, breaches the cladding, and is dispersed into the pool. The assumption is that the peak target was operated at full power for 25 days prior to the failure.

Consequence Analysis

In the event of complete U foil melting, cladding failure, and dispersion of the radionuclides in the reactor pool for a peak target, the downwind dose to a member of the public can be calculated using Table 13a.2-3 and an MRF of 1.0. A peak target location has a peak target-to-target-average power value of 1.18 from Subsection 4a.5.3.5. A maximum reactor power of 2.0 megawatts thermal (MWt) operation versus a 1.8 MWt nominal reactor power results in an additional peaking of 1.11. A peak target power of 30 kWt x 1.18 x 1.11 = 39.3 kWt for 25 days of burnup is analyzed. The results are as follows for the noble gases, halogens, other fission products, and actinides.

Stack release at 600 m (1969 ft.):

$$noble\ gases \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11\ = 0.032\ rem$$

$$halogens \Rightarrow\ 7.38E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.029\ rem$$

$$other\ fission\ products \Rightarrow\ 4.08E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11\ = 0.016\ rem$$

$$actinides \Rightarrow\ 4.36E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.0017\ rem$$

$$Total \Rightarrow\ 0.079\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases \Rightarrow\ 3.31E-3\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11\ = 0.130\ rem$$

$$halogens \Rightarrow\ 3.46E-3\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.136\ rem$$

$$other\ fission\ products \Rightarrow\ 1.91E-3\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11\ = 0.016\ rem$$

$$actinides \Rightarrow\ 4.36E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.075\ rem$$

$$Total \Rightarrow\ 0.357\ rem$$

A TEDE of 79 millirem (mrem) for a stack release and 357 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

At 2500 m (1.6 mi.) (i.e., closer than the nearest resident), assuming that the wind is blowing in a west-northwest direction from the RF, a TEDE of 45 mrem for a stack release and 56 mrem for a ground release are calculated. The prevailing wind direction at the EIPC site is from the south.

There is no requirement for RF high bay ventilation exhaust stack filtration for the halogens, other fission products, or actinides. If the ST was released from the RF high bay directly to the environment as a ground release, the TEDE for a member of the public remains below the accident dose criterion of 1.0 rem. Therefore, the RF high bay ventilation system is not designated as an ESF.

For the worker, it is assumed that the noble gases and halogens are released by diffusion from the pool and immediately fill the RF high bay uniformly. The worker is in the RF high bay when the accident occurs. The radiation alarms sound, and the worker leaves the high bay within 1 min. The TEDE dose to the worker is calculated to be:

$$noble\ gases \Rightarrow\ 2.4E-2\frac{rem}{kW}\ \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.94\ rem$$

$$halogens \Rightarrow\ 2.5E-2\frac{rem}{kW}\ \times 1.0\ \times 30\ kW\ x\ 1.18\ x\ 1.11 = 0.98\ rem$$

for a total of 1.9 rem TEDE for the worker in the RF high bay during the accident. This value is below the 5-rem limit for the worker. The worker thyroid dose is 32.6 rem, which is below the 50-rem limit.

Technical Specification Considerations

An important assumption of the evaluation is that the reactor pool retains the halogens, other fission products, and actinides during the MHA. To support the assumption of reactor pool integrity, the reactor pool concrete structure and base mat and transfer canal concrete structure and base mat are safety-related SSCs.

13a.2.3.2 Insertion of Excess Reactivity

Accidents involving the insertion of excess reactivity are bounded by IER-1, Inadvertent control rod bank withdrawal and IER-2, Prompt insertion of excess reactivity from activation canister ejection. The design and operation of the reactor core preclude other methods for rapid insertion of positive reactivity such as by control rod, safety rod, or target insertion.

IER-1 – Ramp insertion of excess reactivity from control rod bank withdrawal

The control rod bank (four control rods operated together in parallel as a bank) is continuously withdrawn inadvertently, resulting in a power increase and possible overheating of the targets if unmitigated by a scram. The insertion of reactivity inadvertently by the operator or by mechanical failure is considered a not-unlikely event.

Scenario Development

The reactor control system is made up of one safety rod and four control rods. To start up and operate the reactor after shutdown, preoperational startup conditions must be satisfied as described in Chapters 4a and 7a. Once these conditions have been satisfied, the reactor is ready to be operated by establishing a critical condition and then incrementally increased to full power. As described in Subsection 4a.5.3.2, the four control rods and safety rod are initially at their fully inserted, most negative reactivity position. The safety rod is fully withdrawn to the full-out position during the startup sequence with the neutron source inserted into the core and the reactor protection system (RPS) low source level (low power level) detecting the minimum neutron flux. The excess reactivity required to take the core from a clean-cold critical condition to a full power condition of 1.8 MWt is about [[ ]]$^{PROP/ECI}$ at equilibrium Xe-135 conditions (measured in dollar reactivity units). The control rod bank worth is approximately [[ ]]$^{PROP/ECI}$. The control rods are independently operated by individual motor drives but are driven together as a bank. To attain full power from a shutdown condition, the control rod bank is mechanically removed from the core at a defined rate of speed by the operator using a toggle switch at the control console. Once a critical condition is achieved, the neutron source is mechanically removed from the core. The operator continues to drive the control rod bank from the core until the reactor achieves a positive period. As the reactor core increases in power, reactor core and coolant heat up, adding negative reactivity to the system. Additional reactivity is added by the operator until full-power operating conditions are established. Once steady-state full-power operating conditions are achieved, reactivity is adjusted manually or by switching to an automatic servo operation.

The accident initiator assumes that at some time during the operation sequence; either subcritical, critical at low power, or critical at or near full power conditions, the control rod bank is inadvertently driven from the core adding reactivity beyond that desired by the operator. This could happen in several different ways, including operator error, failure of the electrical switch in the toggle to disengage, or failure of the automatic servo. If this event does happen and unexpected movement of the control rod bank is observed by the reactor operator, the operator manually scrams the reactor. However, if the operator does not detect the inadvertent control rod bank motion, provisions are included in the system for a scram (reactor trip) to be initiated automatically by the RPS.

Power and Period Trips

As described in Subsection 7a.4, the RPS consists of a minimum of two (or three with 2-out-of-3 voting logic) wide range nuclear instrument (WRNI) channels, each with a period scram bistable trip and low power/loss of signal scram bistable trip, and a minimum of two (or three with 2-out-of-3 voting logic) power range nuclear instrument (PRNI) channels, each with a high-power scram bistable trip. With two WRNI and two PRNI channels operating, a single trip in any one of the six bistables (two power, two period, and two low power) is sufficient to cause a scram that de-energizes the magnet power supply and subsequently the electromagnets holding the four control rods and one safety rod armatures. Two WRNI channels and two PRNI channels must be fully operational during reactor operations. Operability of the RPS with the reactor in the operating mode is required as a TS limiting condition for operation.

The purpose of the power channel trip is to ensure that the reactor core operating power is not exceeded during normal and abnormal conditions beyond an established acceptable operating value. The purpose of the period channel trip is to ensure that, as reactivity is added to the core, the reactor power does not increase too rapidly such that the power level exceeds conditions of acceptability. Both power and period scram features are required.

This accident investigates the accident category of excess reactivity insertion into the core. As part of this investigation, four key parameters were studied. The results are used to identify controls such that safe operation of the reactor is maintained during subcritical, critical, and full-power operation. The four parameters are as follows:

- Power level trip setting.
- Period level trip setting.
- Reactivity insertion rate.
- Delay time between initiation of a bistable trip and start of downward control rod and safety rod motion into the core.

Item 4, the delay time between initiation of a bistable trip and start of downward control rod and safety rod motion into the core, is dependent on the time duration from the bistable trip to de-energizing the control/safety rod armature electromagnets. This delay time is a measured value that is included in the annual surveillance requirements. For this analysis, the delay time is assumed to be 0.5 s or less.

The power level trip (Item 1) is used to ensure that the target critical heat flux (CHF) is not exceeded under normal operating conditions and anticipated transients. The CHF is discussed in detail in Subsection 4a.6.7. The targets are designed to operate at an average power level of 30 kWt each. For the 60-target baseline core configuration described in Subsection 4a.5.3.5, the maximum target-to-target-average peaking factor is 1.18. At a target average power of 30 kWt, the reactor power is 1.8 MWt. Setting the power level trip at 2.0 MWt allows for 111 percent of the full-power operating condition and maintains a factor of two for the minimum critical heat flux ratio (CHFR) when the core inlet coolant temperature is maintained below 45°C (113°F) as described in Subsection 4a.6.7.

The period trip is used to ensure that the rate of increase in the reactor power is controlled from startup through full-power operating conditions. The selection of the values for the period level trip settings (Item 2) and the reactivity insertion rate (Item 3) is a tradeoff between controllability of the reactor power and efficiency in operating from startup to full power. Too low of a reactivity addition rate and/or too short of a period level trip makes reactor startup to full power very time consuming. On the other hand, too high of a reactivity addition rate and too long of a period level trip could jeopardize the control of the reactor from startup to full power. There is some flexibility in the values chosen for both the period level trip and the reactivity insertion rate. Typically for research reactors, the period level trip is on the order of a few seconds, and the reactivity insertion rate is on the order of tens of cents per second.

Point reactor kinetics calculations were performed to determine values for the power level trip setting (Item 1), period level trip setting (Item 2), reactivity insertion rate (Item 3), and delay time (Item 4) appropriate for the all-target reactor core. Analyses were performed for the starting condition with the reactor critical at 1.0 MWt reactor power, with the reactor critical at 1.0

milliwatt thermal (mWt) reactor power, and with the reactor subcritical by $2.00 with a 1.0 mWt reactor power. Calculations were performed without any reactivity feedback.

The results show that, starting from critical, for both the 1.0 MWt condition and the 1.0 mWt condition, an instantaneous period of 5 s occurs at 2.2 s for a reactivity addition rate of $0.10/s. At that point in time $0.22 of reactivity has been added to the system. If the reactivity addition rate is terminated at that time, the stable reactor period is about 26 s. The reactor power increases by a factor of about 10 every minute. For the $2.00 subcritical starting condition, an instantaneous period of 5 s occurs at about 21 s. At that point in time about $0.10 of positive reactivity has been added to the system.

If a larger reactivity addition rate is used, the instantaneous period of 5 s occurs much earlier in time, less than 1 s for an addition rate of $0.15/s or greater. If a slower reactivity addition rate is used, the instantaneous period of 5 s occurs much later in time, greater than 7 s for an addition rate of $0.05/s or less.

A reactivity addition rate value of $0.10/s with a 5 s period trip represents an optimum balance between operability and controllability. If the reactor is shut down by more than $10, and the differential reactivity worth of the control and safety rods at both ends of the stroke is much less than the peak value, the time required to go from a shutdown condition to critical could be excessive. If the differential reactivity worth of the control rod bank and the safety rod were constant and uniform, then the time required to add $10 of reactivity is about 100 s for a $0.10/s insertion rate. However, because the peak differential worth is used to set the reactivity addition rate and the differential worth curves have a cosine squared shape, achieving the critical condition could take tens of minutes or more if the reactivity insertion rate chosen is too low.

A 5 s period trip allows for $0.20 to $0.25 of reactivity to be added to the system above the critical condition. As noted above, a $0.22 reactivity addition equals a 26 s period. The reactor power increases by a factor of 10 every minute. This means going from 1 mWt at the critical condition to 1 MWt takes about 9 min., with no reactivity feedback, which is an acceptable value. The operator is required to achieve the critical condition at several points from the initial critical condition to full power. As the reactor power increases, heating of the targets and coolant water adds some quantity of negative reactivity to the system, requiring additional adjustments in reactivity by the operator.

A delay time of 0.5 s between the bistable trip and start of downward rod motion into the core is acceptable for a period level trip of 5 s and a reactivity insertion rate of $0.10/s. For an initial condition of critical at 1 MWt, a $0.10/s reactivity addition rate, a period trip of 5 s, and a delay time of 0.5 s, the maximum reactor power that is achieved is about 1.5 MWt before downward control and safety rod motion begins. If the initial condition was 1.8 MWt, the power level trip at 2 MWt occurs before the period level trip.

The conclusion from this analysis is that with the following RPS channel settings and operational constraints, the reactor can be operated safely and efficiently from shutdown to full power operation:

- Power level trip setting = 2 MWt.
- Period level trip setting = 5 s.
- Reactivity insertion rate = $0.10/s.

- Delay time = 0.5 s.

High-Power Condition

This scenario investigates an uncontrolled control rod bank withdrawal for the initial condition with the reactor at critical at 1 MWt steady-state power level. It is assumed that the system has greater than $1.00 of reactivity available to be added. The amount of excess reactivity available with the reactor at full power and at equilibrium Xe-135 conditions is the amount of reactivity required to maintain criticality at full power until the next target changeout and the excess reactivity required to restart the reactor after target changeout due to the Xe-135 buildup after shutdown (see Subsection 4a.5.3.4). The excess reactivity required could be on the order of $1.00 if, during shutdown, the target changeout can be performed in a timely manner. Under this scenario, the initiating event is that the reactor operator inadvertently and continuously adds $0.10/s of reactivity or that a contact relay malfunctions and reactivity is added continuously at $0.10/s. Under either of these conditions the operator could take corrective action and manually scram the reactor, which terminates the accident and shuts down the reactor. If operator action was not taken, the period or power trip terminates the accident and shuts down the reactor.

Because the reactor starting condition is at a steady-state power of 1 MWt, the coolant flow through the core is assumed to be well established and the fuel/cladding temperature at 130°C (266°F). Figure 13a.2-1 shows the results for reactor power as a function of time for a reactivity addition rate of $0.10/s for the initial conditions with the reactor at critical at 1 MWt. Shown also on the plot is the reactivity insertion and the water temperature, water voiding, and fuel temperature negative reactivity feedback effects. The negative feedback effects are calculated from the neutronic results discussed in Subsection 4a.5.3.3. The results of this analysis are qualitative, with the results showing the negative effects as a function of reactor power and energy deposition.

The qualitative results show that if the period trip functions as intended, a reactor scram occurs at 2.24 s. At this time, the reactor power level is 1.39 MWt. Assuming a 0.5 s delay before downward rod motion (2.74 s), the reactor power level is 1.55 MWt when the accident is terminated by the scram. Hypothetically, if both period trips fail, either because they were miscalibrated or because of bistable failures in the RPS, the power level trip at 2 MWt causes a reactor scram at 3.73 s. Assuming a 0.5 s delay before downward motion (4.23 s), the reactor power level is 2.35 MWt when the accident is terminated. If either trip function is successfully actuated, no detrimental effects result. The CHF analysis in Subsection 4a.6.7 shows that the CHF is not exceeded until the reactor power level exceeds at least 3.6 MWt (60 kWt per target) for an inlet coolant temperature of 70°C (158°F) and 5.4 MWt (90 kWt per target) for an inlet coolant temperature of 20°C (69°F).

Low-Power Condition

This scenario investigates an uncontrolled control rod bank withdrawal for the initial conditions with the reactor at critical at 1 mWt steady-state power level. It is assumed that the system has greater than $1.00 of reactivity available to be added for the event. Under this scenario, the initiating event is that the reactor operator inadvertently and continuously adds $0.10/s of reactivity or that a contact relay malfunctions and reactivity is added continuously at $0.10/s. Under either of these conditions the operator could take corrective action and manually scram the reactor, which terminates the accident and shuts down the reactor. If operator action was not taken, the period or power trip terminates the accident and shuts down the reactor.

The difference between this scenario and the previous high-power condition is that for this case, no significant coolant flow is assumed to exist through the reactor core, simulating a startup accident. Because the initial power level is low, there is also no significant heat flux or temperature in the targets. Figure 13a.2-2 shows the results for reactor power and energy as a function of time for a reactivity addition rate of $0.10/s for the initial conditions with the reactor at critical at 1 mWt. Shown also on the plot is the reactivity insertion and the fuel/cladding temperature and negative reactivity feedback. The negative feedback effects are calculated from the neutronic results discussed in Subsection 4a.5.3.3. The results of this analysis are qualitative, with the results showing the negative effects as a function of reactor power and energy deposition.

The results show that if the period trip functions as intended, a reactor scram occurs at 2.24 s. At this time, the reactor power level is 1.39 mWt. Assuming a 0.5 s delay before downward rod motion (2.74 s), the reactor power level is 1.55 mWt when the accident is terminated by the scram.

Consequence Analysis

No consequences occur for the uncontrolled control rod bank withdrawal accident if the RPS period and power level trips function as designed. For all scenarios, a period trip of 5 s terminates the accident scenario, assuming a 0.5 s delay time between actuation of a bistable trip and start of downward rod motion into the core.

The period trip and the power level trip are not expected to be challenged during normal operating conditions. Although the initiator is considered a not-unlikely event, reactor operator training should preclude the initiator from occurring. The operator is fully trained on the procedures for bringing the reactor from shutdown to critical and to full-power operating conditions.

Technical Specification Considerations

- Two RPS WRNI channels are required to be operating for any condition where the safety rod or control rods are driven out of the core into a more reactive position.
- A WRNI channel measures the neutron flux over the full operating range, from startup to full power.
- A WRNI channel maintains a calibrated period trip bistable and a low power/loss of signal trip bistable.
- Two RPS PRNI channels are required to be operating for any condition where the safety rod or control rods are driven out of the core into a more reactive position.
- A PRNI channel measures the neutron flux over the power operating range.
- A PRNI channel maintains a calibrated high-power level trip bistable.
- With two WRNI channels and two PRNI channels operating, a single trip in any of the six bistables causes a reactor scram.
- If three WRNI channels and three PRNI channels are used, a 2-out-of-3 voting logic is required to cause a reactor scram.
- The delay time from initiation of a scram actuation, to start of control and safety rod motion downward into the core is 0.5 s or less.

- The operating power level for the reactor is 1.8 MWt or less.
- The power level trip is 2.0 MWt or less.
- The reactor period level trip is 5 s or greater.
- The maximum reactivity addition rate for the control rods driven as a bank is $0.10/s or less.

IER-2 – Prompt insertion of excess reactivity from activation canister ejection

A negative worth activation canister is rapidly removed from the reactor core with the reactor at full power, resulting in a power increase and possible overheating of the targets. The insertion of reactivity inadvertently by mechanical failure is considered an unlikely event.

Scenario Development

The reactor core has locations where activation canisters are placed to irradiate materials for days or weeks. These canisters are designed to fit in the upper and lower grid plates in the core using similar end fittings as targets and to maintain negative buoyancy. Canisters are removed and replaced in the core using a manual handling tool during scheduled target changeout periods. The reactor is subcritical during activation canister changeout.

This accident scenario assumes that the reactor core is at full power when an activation canister is rapidly ejected from the core due to loss of negative buoyancy. The activation canister is assumed to have a negative reactivity worth, thus inserting positive reactivity instantaneously into the reactor system.

Assuming a negative reactivity worth of $0.50 and rapid ejection of the activation canister, there would be a prompt jump in the reactor power level. A reactor scram occurs immediately from a reactor period level trip of 5 s or greater. However, due to the delay time of 0.5 s or less, the control and safety rod insertion is not immediate. Once downward rod motion begins, and negative reactivity is added to the core, the reactor power level decreases.

A simplistic quantitative analysis assumes that the additional heating of the targets during the transient is adiabatic in the target U foil and the cladding, and prompt feedback is only due to the fuel temperature feedback. Under these assumptions, the peak target could increase in temperature by approximately 110°C (198°F).

Consequence Analysis

No consequences occur for the rapid insertion of $0.50 of reactivity into the reactor at full power. The reactor is shut down by a period scram with a delay time of 0.5 s. During the transient, the peak target temperature could increase by approximately 110°C (198°F), but no fuel melting or target cladding failure occurs.

Technical Specification Considerations

- Activation canisters are limited to individual negative reactivity worths of less than $0.50.
- Activation canisters are designed to fit within the upper and lower grid plates of the core and to maintain negative buoyancy.

13a.2.3.3 Loss of Coolant

LOC-1 – Partial loss of coolant

The reactor pool water level decreases, either due to a leak or break in the primary side of the coolant heat rejection system, a leak or break in the primary coolant cleanup system, or operator error inadvertently removing water from the pool. With the reactor at full operating power, the pool water heats up, allowing for the potential overheating of the targets. A partial loss of coolant from the pool by operator error or mechanical failure is considered a not-unlikely event.

Scenario Development

This event describes the scenario for a partial loss of water from the reactor pool by methods other than a leak in the pool liner. The reactor pool and liner are described in more detail in Section 4a.3. The coolant heat rejection system, primary coolant cleanup system, makeup water system, and overflow system are described in detail in Chapter 5a. The scenario assumes water is removed from the pool inadvertently without the knowledge of the RF operator while the reactor is at full-power level. This could occur in several different ways including:

- A leak or break in the primary coolant line – either the intake or return line.
- A leak or break in the primary coolant cleanup system.
- A leak in a seal on a pump, flange, or valve in the primary coolant system.
- A leak in the heat exchanger or cleanup resin beds.
- Operator error (inadvertent manual line up of valves to remove water from the pool).

Any water removed from the reactor pool is retained in the liquid effluent control system (LECS). A description of the LECS is presented in Subsection 11.2.2. If the water is removed from the pool by a break or leak, the water is captured in the auxiliary equipment room in the high bay and pumped to the LECS using an automatic sump pump. It is assumed that when the event occurs, the reactor is operating at full-power level.

Several design features are incorporated into the RF to limit the amount of water that can be removed from the pool. Most importantly, the intake lines that are in the pool for both the primary coolant system and the primary coolant cleanup system extend 3.2 m (10.6 ft.) or less below the pool “filled” level. No other lines extend into the pool that can remove water. For a 3.66 m (12 ft.) diameter tank, approximately 33,900 liters (L) (8950 gallons [gal.]) of water (approximately 33.5 percent of the total pool volume) could be removed from the pool for an intake line that extends 3.2 m (10.6 ft.) into the pool. The LECS is sized to accommodate 113,400 L (30,000 gal.) of water.

The balance of plant (BOP) system at the control console includes reactor pool water level indication and reactor pool water level alarms to allow the operator to continuously monitor the reactor pool water level in the pool. If the reactor pool water level drops below the nominal operating value, a water level alarm is actuated by the BOP system. If a sump pump is automatically actuated, pumping water to the LECS, a sump pump alarm is actuated by the BOP system. Regular surveillance walkthroughs of the RF are planned during the operational shift and any deviations in reactor pool water level are promptly reported to the RF supervisor. If the reactor pool water level continues to drop, a low reactor pool water level scram is initiated as

described in Subsection 7a.4.2. A manual scram switch is in the reactor control room for the operator to take immediate action and shut down the reactor.

Subsection 4a.6.7 describes operating conditions for the reactor, including pool water height and reactor coolant flow rates. When at the filled level, the saturation temperature for the water at core level is 113°C (235°F). At 1.5 m (4.9 ft.) below the filled level, the saturation temperature is 109.8°C (229.6°F). This value is only 3.2°C (5.8°F) less than for the filled condition and is adequate for full power 1.8 MWt operation of the reactor.

The RF operator acts to shut down or manually scram the reactor if it is determined that an abnormal condition exists in the coolant heat rejection system or the primary coolant cleanup system and that the reactor pool water level is decreasing in the pool. If the operator does not act to shut down the reactor, the low pool coolant level scram initiates a reactor scram. The reactor pool water level could continue to decrease in the pool until the reactor pool water level dops to 3.2 m (10.5 ft.) below the filled level. At that point, no additional water can be removed from the pool.

Assuming that the reduction in the water height is due to a break in the coolant heat rejection system, return line water (cold leg) is not returned to the pool. The pool water continues to heat up until operator action was taken or a core coolant inlet temperature scram, described in Subsection 7a.4.3, occurred. Assuming the pool initially had 101,000 L (26,700 gal.) of water (excluding the water in the transfer canal), the heat-up rate of the pool is about 0.25°C (0.45°F) per minute. If 33.5 percent of the water is removed from the pool, the pool heat-up rate is about 0.38°C (0.68°F) per minute. As described in Subsection 4a.6.7, a factor of two in the minimum CHFR can be maintained when the core inlet coolant temperature is less than or equal to 45°C (113°F). As described in Section 7a.4, a core coolant inlet temperature scram in the RPS ensures that the CHF for the targets is not exceeded.

Consequence Analysis

No fuel melting or cladding failures occur for this accident scenario. No consequences occur for a partial loss of water from the pool.

Technical Specification Considerations

- A pool coolant level monitoring channel is included in the RPS. A low pool coolant level scram is initiated if the level falls below 1.5 m (4.9 ft.) from the filled level.
- Core coolant inlet temperature monitoring channels are included in the RPS. The core coolant inlet temperature scram is initiated if the temperature exceeds 45°C (113°F).
- The primary coolant system intake and the primary coolant cleanup system intake extend 3.2 m (10.6 ft.) or less below the pool filled level.

13a.2.3.4 Loss of Coolant Flow

LOF-1 – Loss of cooling system flow

LOF-2 – Loss of cooling system heat sink

A loss of functionality in the coolant heat rejection system or loss of flow of the primary coolant pumps with the reactor at full power causes the pool water to heat up, potentially overheating

the targets. The loss of cooling system heat sink and loss of cooling system flow are considered not-unlikely events.

LOF-3 – Overheating of a target due to flow blockage

A loss of flow through the core due to a partial or complete blockage of the flow holes in the lower grid plate with the reactor at full power causes the core water to heat up, potentially overheating the targets. The partial loss of water flow through the core is considered a not-unlikely event.

Scenario Development

Loss of cooling system flow (LOF-1) and Loss of cooling system heat sink (LOF-2)

This event describes the scenario for the loss of the cooling system flow (LOF-1), or the loss of the cooling system heat sink (LOF-2). The scope of these accidents scenarios are within a broader class of accidents involving the failure of the coolant heat rejection system where the pool water temperature continues to increase.

The coolant heat rejection system is described in detail in Sections 5a.2 and 5a.3. The scenario assumes the coolant heat rejection system malfunctions without the knowledge of the RF operator while the reactor is at full-power level. This could occur in several different ways including:

- Failure or malfunction in the secondary side of the coolant heat rejection system (secondary side pumps or secondary cooling system fails).
- Failure of the primary coolant pumps to operate.
- Operator inadvertent action, turning off pumps in the primary or secondary cooling system.
- Faulty indications lead the operator to perform incorrect action, turning off equipment unnecessarily.

The design of the coolant heat rejection system includes redundancy in the primary coolant pumps, heat exchangers, secondary coolant pumps, and secondary cooling system. The operation of the system is controlled at the control console using the BOP system. The BOP displays and records temperatures, flow rates, and functionality of the coolant heat rejection system. If the BOP determines that the coolant heat rejection system is performing outside of its normal operating range, out-of-range warning indications are actuated.

The RF operator acts to shut down or manually scram the reactor if it is determined that an abnormal condition exists in the coolant heat rejection system. The operator may take corrective action using a redundant feature in the coolant heat rejection system, such as turning on an alternate pump. However, if the proper operating conditions cannot be restored within a reasonable period, the reactor is shut down by the operator for further evaluation of the conditions.

If the operator does not act, the reactor continues to operate at full power. The reactor pool continues to heat up until operator action is taken. Assuming the initial average temperature of the pool, under full power conditions, is 40°C (104°F), and the pool initially has 101,000 L (26,700 gal.) of water (excluding the water in the transfer canal), the heat-up rate of the pool is

about 0.25°C (0.45°F) per minute. As described in Subsection 4a.6.7, a factor of two in the minimum CHFR can be maintained when the core inlet coolant temperature is less than or equal to 45°C (113°F). Incorporating an inlet coolant temperature scram in the RPS ensures that the CHF for the targets is not exceeded.

Overheating of a target element due to flow blockage

This event describes the scenario for the loss of flow through the core due to a flow blockage in the downcomer or a partial or complete blockage of the flow holes in the lower grid plate with the reactor operating at full power. The scenario is that a piece of material, such as a plastic bag, falls into the pool during a maintenance activity in the RF high bay. The bag is unnoticed by RF staff. During startup, the bag is circulated in the pool and is sucked into the downcomer. It subsequently goes to the bottom of the downcomer and covers the lower grid plate, restricting some or all the flow through the core.

The design of the downcomer inlet includes a screen feature to prevent objects from being sucked into the downcomer. There are no parts in the downcomer or in the lower support structure that could become dislodged or broken off, causing a flow blockage.

If a plastic bag is sucked into the downcomer, it could cover a portion of the lower grid plate and restrict the flow through a portion of the core. If a partial blockage occurred with the reactor at full power, the targets located over the blocked portion of the lower grid plate would still be cooled by the cross flow from the unblocked locations. Cross flow at the bottom inlet to the targets allow for the targets to maintain flow in both the inner and outer flow channels of the targets. A complete blockage is not credible because control and safety rod guide tubes limit the accessibility to the lower grid plate.

Consequence Analysis

No fuel melting or cladding failures occur for this accident scenario. No consequences occur for a loss of heat sink or loss of cooling system flow. No consequences occur for a partial flow blockage of the lower grid plate.

Technical Specification Considerations

Two RPS core coolant inlet temperature monitoring systems are required to be operating for any condition where the safety rod or control rods are driven out of the core into a more reactive position. The core coolant inlet temperature trip is 45°C (113°F) or less.

13a.2.3.5 Mishandling or Malfunction of Targets

MMT-1 – Dropped/mishandled irradiated targets

MMT-2 – Mishandled irradiated target transfer basket

One or several irradiated targets are dropped in the pool during transfer or the irradiated target transfer basket holding irradiated targets falls over, dumping the irradiated targets into the pool or transfer canal. The targets could be breached as a result of hitting the floor or other objects. A dropped or mishandled irradiated target or target transfer basket is considered a not-unlikely event.

Scenario Development

Irradiated target changeout in the reactor core may occur daily or several times a week depending on molybdenum (Mo-99) production demands. The transfer from the reactor core to the irradiated target transfer basket occurs with the reactor shut down. The semi-automatic target handling system is used to move one or several irradiated targets at a time from the reactor core into the irradiated target transfer basket. The irradiated target transfer basket moves the irradiated targets into the HCF target processing canyon through the transfer canal. Fresh targets are added to the core, again using the semi-automatic target handling system and the fresh target transfer basket. Targets can also be removed/replaced individually in the core using a manual target handling tool. More detailed descriptions of the target handling system and the target transfer system are presented in Subsections 9a.2.1 and 9a.2.2.

A unique design feature of the reactor is that 60 targets cannot be made into a critical configuration without a beryllium (Be) reflector. There is no pitch or other target configuration that allows for a critical configuration of 60 targets without the Be reflector. This allows for target handling and transfer to be accomplished without any criticality limitations.

During the handling and transfer process, fresh or irradiated targets could be dropped by the semi-automatic target handling system or by the manual handling tool. The irradiated target transfer basket could be mishandled, dropping all the irradiated targets in the basket into the pool. As the target or targets fall to the bottom of the pool, they could be damaged as they collide with other objects in the pool or the bottom surface of the pool liner. The most likely scenario is that the targets become slightly dented from colliding with other objects as they sink to the bottom of the pool. Target cladding breach is unlikely due to the Al cladding thickness and robust target design.

For this accident scenario, it is assumed that 24 targets are damaged with the target cladding breached, allowing for noble gas fission products to be released into the pool. As discussed in Subsection 13a.2.1.1, by design there are no gaps between the fuel foil and the cladding. The MRF used for this accident is 4E-4.

Consequence Analysis

Assuming cladding failure (puncture) of 24 irradiated targets, and assuming no additional decay of the fission products, the downwind dose from the noble gases to a member of the public can be calculated using Table 13a.2-3 and an MRF of 4E-4 and a PRF of 1.0. The result is as follows for the noble gases for 24 targets operated at 30 kWt each for 25 days.

Stack release at 600 m (1969 ft.):

$$noble\ gases \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 24 = 0.24E-3\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases \Rightarrow\ 3.31E-3\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 24 = 0.95E-3\ rem$$

A TEDE of 0.24 mrem for a stack release and 0.95 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem and are bounded by the MHA.

For the worker, it is assumed that the noble gases are released from the pool and immediately fill the RF high bay uniformly. The worker is in the RF high bay when the accident occurs. The radiation alarms sound, and the worker leaves the high bay within 1 min. The TEDE dose to the worker is calculated to be:

$$noble\ gases \Rightarrow\ 2.4E-2\frac{rem}{kW}\ \times 0.0004\ \times 30\ kW\ x\ 24 = 6.9E-3\ rem$$

for a total of 6.9 mrem TEDE for the worker in the RF high bay during the accident. This value is below the 5-rem limit for the worker.

Technical Specification Considerations

The reactor is subcritical during target changeout.

13a.2.3.6 Experiment Malfunction

EM-1 – Failure of activation/irradiation canister

An activation/irradiation canister fails while being irradiated, resulting in the release of activation products into the reactor pool. This could be due to canister failure or melt of the activation material due to overheating. The rupture of a canister could damage nearby targets. Failure of an activation/irradiation canister is considered a not-unlikely event.

Scenario Development

Materials can be irradiated in the reactor at specified activation locations in the grid structure or the reflector. The production of neutron activation isotopes for medical therapeutic uses is expected at the EMIF. One of these isotopes is lutetium-177, which is produced by neutron activation of lutetium-176 (solid) or ytterbium-176 (solid). These activation materials are packaged for irradiation in specially designed activation/irradiation canisters and placed at a predefined irradiation location in the core or reflector region. The canisters must be designed to include adequate cooling of the material to be irradiated. The canisters are placed and removed from the core using a manual handling tool during the shutdown intervals for target changeout. The irradiated canisters can be stored in the pool for some decay period and then transferred to the HCF using the irradiated target transfer basket, where the material can be processed and packaged for shipment to the customer.

During irradiation, the activation material could overheat due to neutron and gamma-ray heating and breach the canister. Other scenarios could be envisioned where the activation material off-gas causes the canister to leak or burst.

For this analysis, the accident scenario investigated is a failure of an irradiation/activation canister due to over-pressurization and rupture. If the canister was in the reflector region near the targets, the rupture could damage three adjacent targets. No reactivity effects are assumed for the accident. If some voiding occurred, the collapse of the voids would likely cause a period trip and scram the reactor. The release of activated material is determined on a case-by-case basis and shown to be less than the accident dose criterion of 1.0 rem. Limitations on activation irradiations will be discussed in the Operating License Application.

Consequence Analysis

Assuming cladding failure of three targets, the downwind dose from the noble gases to a member of the public can be calculated using Table 13a.2-3 and an MRF of 4E-4. The result is as follows for the noble gases for three targets operated at 30 kWt each for 25 days.

Stack release at 600 m (1969 ft.):

$$noble\ gases \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 3 = 0.029E-3\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases \Rightarrow\ 3.31E-3\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 3 = 0.12E-3\ rem$$

A TEDE of 0.029 mrem for a stack release and 0.12 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem and are bounded by the MHA.

For the worker, it is assumed that the noble gases are released from the pool and immediately fill the RF high bay uniformly. The worker is in the RF high bay when the accident occurs. The radiation alarms sound, and the worker leaves the high bay within 1 min. The TEDE dose to the worker is calculated to be:

$$noble\ gases \Rightarrow\ 2.4E-2\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ x\ 3 = 0.86E-3\ rem$$

for a total of 0.86 mrem TEDE for the worker in the RF high bay during the accident. This value is below the 5-rem limit for the worker.

Technical Specification Considerations

Materials are irradiated in specially designed activation/irradiation canisters that are designed for adequate cooling and containment of the irradiated material.

13a.2.3.7 Loss of Normal Electrical Power

The electrical power systems are described in Chapter 8. There are no accidents identified for the RF from a loss of normal electrical power that are accident initiating events.

LEP-1 – Loss of normal electrical power

A partial or full loss of electrical power to the RF high bay and associated coolant heat rejection system, ventilation system, and auxiliary systems causes a partial or full shutdown of some or all of these systems. Partial or full loss of electrical power to the reactor control room causes a partial or full loss of monitoring capability of the reactor. Partial or full loss of normal electrical power to the RF is considered a not-unlikely event.

Scenario Development

No backup power is required for safe shutdown of the reactor. As described in Subsection 7a.2.2, a loss in electrical power to the magnet power supply scrams the reactor by de-energizing the electromagnets on each of the four control rods and safety rod, allowing them to

fall by gravity into their most negative reactivity position in the core. With the reactor in this shutdown state, there are no requirements for pool cooling, ventilation, or the RF high bay exhaust stack to be functional.

The large volume of the pool water (see Subsection 5a.2.2) results in a very small change in temperature from the decay heat generated from the fission products in the targets with the coolant heat rejection system nonoperational. Ten minutes after shutdown, the decay power is 1.95 percent of the full power value, 35 kWt. At 5.5 hr., the decay power is 0.58 percent, 10 kWt and at 11 hr., 0.43 percent, 7.8 kWt. For a pool volume of 101,300 L (26,700 gal.) of water (excluding the volume in the transfer canal), the pool heat-up rate, using a decay power of 7.8 kWt, is about 0.07°C (0.13°F) per hour. This heat rate is insignificant compared to heat losses from the pool to the surrounding concrete liner.

A partial loss of electrical power could occur under several different scenarios for the RF high bay and the reactor control room. Depending on the scenario, different equipment and systems could be affected by the outage. The RF operator manually scrams the reactor if it is deemed that the RF has lost partial electrical power.

During a loss of normal electrical power, the reactor and subsystems are not required to be monitored. There is no emergency power or backup power required for the RF. With a full or partial loss of normal electrical power the RF can be left in a shutdown state. No operations or work is performed at the RF under this condition.

Consequence Analysis

No consequences occur for the partial or full loss of normal electrical power to the RF high bay or to the reactor control room.

Technical Specification Considerations

The RPS is designed fail-safe. All control and safety rods fall by gravity to their most negative reactivity position when electrical power is lost to the magnet power supply. There are no TS considerations for loss of normal electrical power.

13a.2.3.8 External Events

EE – Postulated external events

Earthquake

As described in Subsection 2.5.3, the project site near Eunice, New Mexico, is in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the EIPC is low.

Significant earthquakes are not known to occur within the vicinity of the EIPC. Most of the recorded earthquakes have low-to-moderate magnitudes (between 2.5 and 5.0). Subsection 2.5.3 summarizes the earthquakes within an approximately 100-mi. (161-kilometer) area surrounding the project site with a magnitude of 4.0 or greater between 1950 and 2022. Section 3.4 describes the design basis earthquake characteristics that are the design input for the safety-related portion of the EMIF. By designing the safety-related portion of the EMIF in

accordance with the approach described in Section 3.4 it is capable of resisting the design basis seismic loads.

The nonsafety-related portion of the EMIF is designed to local building code requirements and for the extreme environmental loads discussed in Sections 3.2 through 3.4. Thus, the nonsafety-related portion of the EMIF main force resisting system is designed to prevent collapse during a design basis seismic event to ensure it does not negatively impact the safety-related portion of the EMIF.

Tornado or High Winds

Tornado and high wind hazards are described in Section 2.3 and an analysis of the ability of the RF to withstand extreme winds is presented in Section 3.2. The design of the EMIF provides protection for safety-related SSCs against adverse effects from winds.

The safety-related structural walls of the RF that surround the reactor are designed to survive credible wind and tornado loads, including missiles, as described in Sections 3.2 and 3.4.

The SSCs whose failure during a tornado event could affect the safety-related portions of the facility are designed to resist the tornado loading or, alternatively, the effect on the safety-related structures from the failure of these SSCs, or portions thereof, is evaluated to ensure no safety function is compromised. As described in Sections 3.2 and 3.4, protection of safety-related SSCs from tornado missile impacts is achieved as follows. Structural components of safety-related structures are designed for both local and global damage due to tornado missile impacts. Safety-related structure, system, or component within the safety-related structures not exposed by openings or penetrations are therefore protected from damage caused by tornado missiles. Further analysis is conducted to ensure that the openings within the safety-related structures do not expose safety-related SSCs to an unacceptable probability of tornado missile impact.

Precipitation

The meteorological characterization of the EIPC site defines the precipitation characteristics (see Section 2.3). The approach to translating the characteristics of design basis precipitation for the site into loads on the EMIF is described in Subsection 3.2.3.

External Flood

As further described in Sections 2.4 and 3.3, the potential for external flooding of the RF results from local intense rainfall. Protection against flooding is provided by establishing the facility floor level above the finished grade elevation and all roads below this elevation. Diversion ditches are strategically located around the site to deflect surface runoff from adjacent land away from the facility structures on the site.

Section 3.3 describes the design basis flood parameters for the safety-related portion of the EMIF. There are no external flood loads on the above-grade portion of the EMIF. The portion of the EMIF below-grade (e.g., reactor pool, transfer canal, waste storage canyon, HCF target fabrication area, and other HCF basement areas) is designed to withstand buoyant forces and groundwater, including groundwater associated with the design basis flood.

Off-site Stationary and Transportation Accidents

As described in Section 2.2, the facilities and routes within 5 mi. (8 km) of the EIPC were evaluated to determine the hazards:

- An uninhabitable reactor control room due to toxic vapors.
- Damage to EIPC structures due to explosive overpressure from stationary explosions.
- Damage to EIPC structures due to explosive overpressure from delayed ignition explosions.
- Damage to safety-related structures and equipment due to radiative heat transfer.

The results of these analyses concluded that none of the chemical sources, off-site facilities, or transportation routes pose a hazard to the EIPC.

Consequence Analysis

Due to the RF design features, there are no consequences to members of the public or to the worker because of postulated external events.

Technical Specification Considerations

None.

13a.2.3.9 Mishandling or Malfunction of Equipment

MME-1 – Heavy load drop on reactor core

A heavy load is dropped onto the reactor core resulting in damage to the targets. A heavy load dropped on the reactor core is considered a not-unlikely event.

Scenario Development

For any heavy-load related maintenance activity above the pool or for any crane operation above the pool, the reactor is in a shutdown condition. RF operation's staff determine if the core needs to be unloaded before heavy load movement. During a maintenance activity with the reactor shut down after a full-power operation, the load is accidentally dropped onto the core either due to a crane malfunction, operator error, or improper/failed rigging.

For this accident scenario, it is assumed that all 60 targets are damaged and the target cladding breached allowing for noble gas fission products to be released into the pool. As discussed in Subsection 13a.2.1.1, by design there are no gaps between the fuel foil and the cladding. The MRF used for this accident is 4E-4.

Consequence Analysis

Assuming cladding failure of all 60 targets in the core and no additional decay of the fission products, the downwind dose from the noble gases to a member of the public can be calculated using Table 13a.2-3, an MRF of 4E-4, and a PRF of 1.0. The result is as follows for the noble gases for 60 targets operated at 30 kWt each for 25 days.

Stack release at 600 m (1969 ft.):

$$noble\ gases \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 60 = 0.59E-3\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases \Rightarrow\ 3.31E-3\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ \times 60 = 2.38E-3\ rem$$

A TEDE of 0.59 mrem for a stack release and 2.38 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem and are bounded by the MHA.

For the worker, it is assumed that the noble gases are released from the pool and immediately fill the RF high bay uniformly. The worker is in the RF high bay when the accident occurs. The radiation alarms sound, and the worker leaves the high bay within 1 min. The TEDE dose to the worker is calculated to be:

$$noble\ gases \Rightarrow\ 2.4E-2\frac{rem}{kW} \times 0.0004\ \times 30\ kW\ x\ 60 = 1.73E-2\ rem$$

for a total of 17.3 mrem TEDE for the worker in the RF high bay during the accident. This value is below the 5-rem limit for the worker.

Technical Specification Considerations

- No heavy-load related maintenance activities are performed over the reactor pool with the reactor operating.
- No crane operations are conducted over the reactor pool with the reactor operating.

Table 13a.2-1
Pool Release Fractions

Chemical Group	PRF
Noble gases	1.0
Halogens	0.005
Others	0.00071

Abbreviations: PRF = pool release fraction

Table 13a.2-2
χ/Q and FCCF for F Stability, 1 m/s

Distance from RF Exhaust Stack or Building (m)	Stack Release χ/Q (s/m^3)	Ground Release χ/Q (s/m^3)	Finite Cloud Correction Factor (FCCF)
400	0.000337	0.00267	0.081
500	0.000392	0.00191	0.096
600	0.000407	0.00145	0.111
700	0.000400	0.00115	0.124
800	0.000383	0.000942	0.138
900	0.000361	0.000788	0.150
1000	0.000338	0.000672	0.162
2500	0.000135	0.000169	0.307

Abbreviations: χ/Q = atmospheric dispersion coefficient | FCCF = finite cloud correction factor | m/s = meters per second | RF = Reactor Facility | m = meter(s) | s/m^3 = seconds per cubic meter

Table 13a.2-3
TEDE and Fraction of Total Downwind Dose for the Noble Gases, Halogens, Other Fission Products, and Actinides for Target Inventory per kWt Irradiated for 25 days

Chemical Group	Stack Release (600 m) TEDE (rem/kWt) – Dose Fraction	Ground Release (500 m) TEDE (rem/kWt) – Dose Fraction
Noble gases	8.16E-4 (0.41)	3.31E-3 (0.41)
Halogens	7.38E-4 (0.37)	3.46E-3 (0.37)
Others fission products	4.08E-4 (0.20)	1.91E-3 (0.20)
Actinides	4.36E-5 (0.02)	2.05E-4 (0.02)
Total	2.01E-3 (1.00)	8.88E-3 (1.00)

Abbreviations: TEDE = total effective dose equivalent | kWt = kilowatt(s) thermal | m = meter(s)

13a.3 SUMMARY AND CONCLUSIONS

Chapter 13a presented nine postulated event categories for accident scenarios for the all-target reactor concept. The summary of the accident dose consequences is presented in Table 13a.3-1. The MHA, a complete melt of a peak target irradiated for 25 days with the fission products dispersed in the pool, bounds all the accident dose consequences. The dose to a member of the public at the 500 m (1640 ft.) boundary is 357.0 mrem assuming a ground release, which is within the accident dose criterion of 1.0 rem. The dose to the worker who remains in the RF high bay for 1 min. following the accident is 1.9 rem, which is within the worker limit of 5 rem.

Table 13a.3-1
Summary of Accident Dose Consequences

Accident Scenario	15 m Stack Release at 600 m TEDE (mrem)	Ground Release at 500 m TEDE (mrem)	Worker TEDE (rem)
MHA	79.0	357.0	1.9
Insertion of excess reactivity	N/A	N/A	N/A
Loss of coolant	N/A	N/A	N/A
Loss of coolant flow	N/A	N/A	N/A
Mishandling or malfunction of targets	0.24	0.95	0.0069
Experiment malfunction	0.03	0.12	0.00086
Loss of normal electrical power	N/A	N/A	N/A
External events	N/A	N/A	N/A
Mishandling or malfunction of equipment	0.59	2.38	0.017

Abbreviations: m = meter(s) | TEDE = total effective dose equivalent | mrem = millirem | MHA = maximum hypothetical accident | N/A = not applicable

13a.4 REFERENCES

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Figure 13a.2-1
Reactor Power and Reactivity Feedback as a Function of Time for a Reactivity Additional Rate of $0.10/s – Starting Conditions Critical at 1 MWt

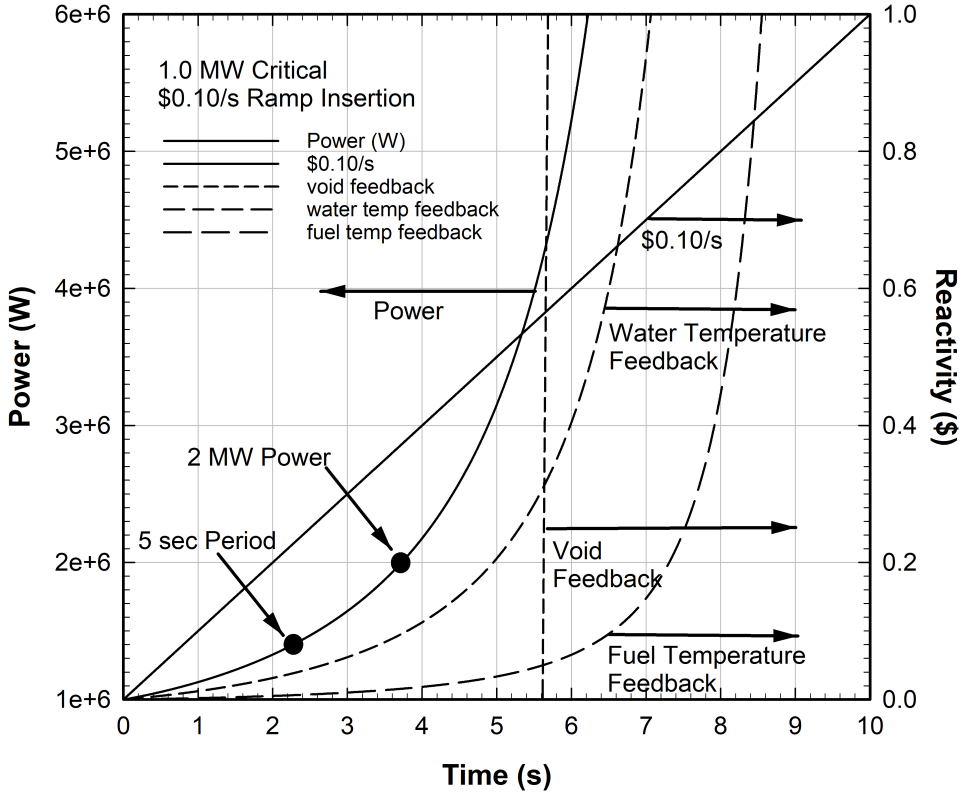
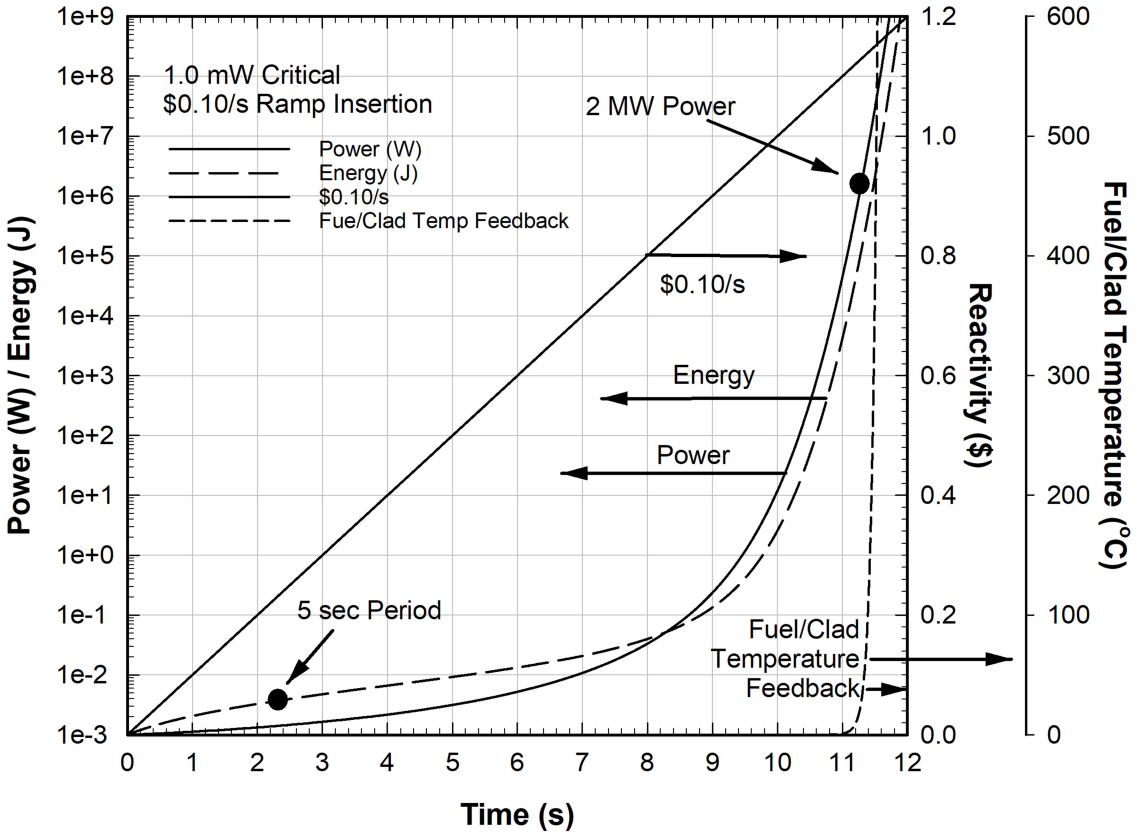


Figure 13a.2-2
Reactor Power and Reactivity Feedback as a Function of Time for a Reactivity Additional Rate of $0.10/s – Starting Conditions Critical at 1 mWt



Eden Isotope Production Complex
Preliminary Safety Analysis Report

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Chapter 13b
Hot Cell Facility Accident Analyses

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CHAPTER 13b
HOT CELL FACILITY ACCIDENT ANALYSES

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
χ/Q	atmospheric dispersion coefficient
$AgNO_3$	silver nitrate
Al	aluminum
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
Br	bromine
$C_{12}H_{26}$	dodecane
$C_{12}H_{27}O_4P$	tributyl phosphate (TBP)
$C_{14}H_{13}NO_2$	alpha benzoin oxime
CAAS	criticality accident alarm system
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
$Cl_3H_6O_3Rh$	rhodium(III) chloride trihydrate
CSDE	cloudshine effective dose equivalent
DCF	dose conversion factor
DF	dose factor
DOE	United States Department of Energy
Eden	Eden Radioisotopes, LLC
EE	external event
EIPC	Eden Isotope Production Complex

Acronym/Abbreviation	Definition
EMIF	Eden Medical Isotope Facility
ESF	engineered safety feature
FCCF	finite cloud correction factor
FGDS	fission gas delay system
ft.	feet
g	gram(s)
gal.	gallon(s)
H2O	water
H2O2	hydrogen peroxide
H_2SO_4	sulfuric acid
HCF	Hot Cell Facility
HCl	hydrochloric acid
HEPA	high efficiency particulate air
HNO_3	nitric acid
hr.	hour(s)
I-131	iodine-131
I-133	iodine-133
I-135	iodine-135
in^3	cubic inches
ISA	Integrated Safety Analysis
ISG	Interim Staff Guidance
kg	kilogram(s)
$KMnO_4$	potassium permanganate
Kr-85	krypton-85
Kr-87	krypton-87

Acronym/Abbreviation	Definition
Kr-88	krypton-88
K_3RuCl_6	potassium hexachlororuthenate
kW	kilowatt(s)
kWt	kilowatt-thermal
L	liter(s)
lb.	pound(s)
LEU	low-enriched uranium
LPF	leak path fraction
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
M	molar
MAR	material at risk
MAWP	maximum allowable working pressure
mg	milligram(s)
MHA	maximum hypothetical accident
mi.	mile(s)
mL	milliliter(s)
Mo-99	molybdenum-99
MO_3	molybdenum trioxide
mol	mole(s)
mrem	millirem
MRF	matrix release fraction
N	normal
NaOH	sodium hydroxide

Acronym/Abbreviation	Definition
NaI	sodium iodide
NCSP	Nuclear Criticality Safety Program
Ni	nickel
NO_x	nitrogen oxides
NRC	United States Nuclear Regulatory Commission
oz.	ounce(s)
PAC	Protective Action Criteria
PEL	permissible exposure limit
POC	production office complex
ppm	parts per million
PSAR	Preliminary Safety Analysis Report
QC	quality control
R&D	research and development
rem	Roentgen equivalent man
RF	Reactor Facility
RR	respiratory rate
s	second(s)
SCB	steel confinement box
SNM	special nuclear material
SSC	structure(s), system(s), and component(s)
ST	source term
TBP	tributyl phosphate
TEDE	total effective dose equivalent
TS	Technical Specification(s)
U	uranium

Acronym/Abbreviation	Definition
U-235	uranium-235
UO_2	uranium dioxide
$UO_2(NO_3)_2$	uranyl nitrate
UPSS	uninterruptible power supply system
UREX	uranium extraction
Xe	xenon
Xe-133	xenon-133
Xe-135	xenon-135
Xe-135m	xenon-135 metastable

13b. Hot Cell Facility Accident Analyses

As stated earlier in Section 1.1, the Hot Cell Facility (HCF) of the Eden Isotope Production Complex (EIPC) is a production facility in that it will be used for the processing of irradiated materials containing special nuclear materials (SNM) meeting Section (3) of the definition in Title 10 of the Code of Federal Regulations (10 CFR) 50.2. This Preliminary Safety Analysis Report (PSAR) is submitted in accordance with the provisions of 10 CFR Part 50, in support of the application by Eden Radioisotopes, LLC (Eden) to construct the EIPC. At the Operating License stage, Eden will apply for a Class 103 facility license per 10 CFR 50.22 (for commercial and industrial facilities) that includes license conditions for the receipt, possession, and use of source material under 10 CFR Part 40, byproduct material under 10 CFR Part 30, and SNM under 10 CFR Part 70.

This chapter, including the appendix, provides the United States Nuclear Regulatory Commission (NRC) with a description of the planned approach to conducting the formal detailed Integrated Safety Analysis (ISA), which will be performed at a later date, as the EIPC design progresses towards final design stage. An ISA Summary will be provided in the Final Safety Analysis Report, and the complete ISA will be available for NRC review during the Operating License stage review process.

Recognizing that this license application is for a Construction Permit under 10 CFR Part 50, Eden has deliberately refrained from utilizing terms related to 10 CFR Part 70, such as “IROFS [items relied on for safety]”, or “Management Measures,” and instead simply used the terms “safety-related,” “engineered safety features (ESFs),” or “potential topics for technical specifications (TS).”

Accordingly, this chapter provides a preliminary analysis of the hazards potentially affecting the HCF. This chapter presents an early analysis of the bounding postulated accidents at the HCF portion of the Eden Medical Isotope Facility (EMIF) based on the preliminary design. This accident analysis applies only to the accidents that could occur at the HCF. It does not cover accidents related to other operations at the EMIF. The accidents that are analyzed in this chapter were identified using the following sources of information:

- NUREG-1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors (Part 1 and 2).
- Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Parts 1 and 2, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content, for Licensing Radioisotope Production Facilities and Aqueous Homogenous Reactors.
- Current preliminary design for the HCF and associated processes.
- Early results of the preliminary ISA based on the preliminary design of the HCF (See Appendix 13b.A).

The accidents that are analyzed in this chapter are bounding events that provide worst case consequences for the categories of events listed in the ISG Augmenting NUREG-1537.

The combination of this chapter and the ISA considers the complete spectrum of events that may occur due to operations at the HCF, analyzes potential radiological and chemical consequences to the public, the worker, and the environment, estimates the likelihood of the

events occurring, and identifies and assesses associated preventive and mitigative features to ensure that the potential radiological consequences are acceptable.

The level of analysis performed to characterize the hazards associated with the HCF is consistent with the complexity, hazard potential, and life-cycle stage of the facility. Due to the limited number of structures, systems, and components (SSCs), primary emphasis is placed on the qualitative hazard screening analysis in the preliminary ISA of all potential credible events. Quantitative analysis is conducted to augment and reinforce the qualitatively assigned consequence estimates of bounding and postulated credible accident scenarios.

No accident initiating events in the HCF have been identified that could affect the operations in the Reactor Facility (RF) or cause a separate initiating event to occur in the RF.

The fabrication of targets at the HCF target fabrication area will occur under a 10 CFR Part 70 SNM license that is separate from the 10 CFR Part 50 utilization and production facility licenses that are the subject of this application. The 10 CFR Part 70 license will be the subject of a future application to the NRC. The target fabrication process is discussed in this chapter to allow a complete description of potential activities within the EMIF. The discussion of target fabrication supports the discussion in Chapter 4a about the safety of the target and reactor design.

13b.1 RADIOISOTOPE PRODUCTION FACILITY ACCIDENT ANALYSIS METHODOLOGY

The regulations in 10 CFR 50.34(a)(i) require the following:

> *"For non-power production or utilization facilities not subject to 10 CFR Part 100, the assessment must provide an evaluation of the applicable radiological consequences that demonstrates with reasonable assurance that any individual located in the unrestricted area following the onset of a postulated accident, including consideration of experiments, would not receive a radiation dose in excess of 1 rem (0.01 [sievert) TEDE [total effective dose equivalent] for the duration of the accident."*

This 1 rem accident dose criterion applies to both the utilization facility (RF) and the production facility (HCF). This is quite different than the 10 CFR Part 70 ISA approach. The requirement is that the analyzed accident release dose to an individual located in the unrestricted area (outside of the controlled area which is the property boundary) must be less than 1 rem for any postulated accident.

Postulated accidents are determined by the development of the maximum hypothetical accident (MHA), that is, the non-credible, bounding, worst-case fission-product release scenario, used to test the facility's safety performance. Doses to an individual located in the unrestricted area from credible fission product release accidents need to be bounded by the MHA, which meets the 1 rem accident dose criterion. Accordingly, credible events can be classified as postulated accident scenarios that are bounded by the MHA. There could be other credible postulated accidents that are not fission product release accidents. These non-fission product release postulated accidents also need to meet the 1 rem accident dose criterion.

Further, Eden must also demonstrate that if a 1 rem unmitigated dose is exceeded, mitigative design features (engineered controls identified as ESFs) must be included that can be shown to be effective in maintaining this 1 rem dose criterion.

Eden's methodology for the HCF Accident Analyses can be summarized as follows:

- Perform a preliminary ISA on the HCF (Production Facility) activities using a 6-step process as described in Appendix 13b.
- Use definitions in NUREG-1520, Standard Review Plan for Fuel Cycle Facilities License Applications, Revision 2, Appendix A for consequence, frequency and risk.
- Use NUREG-1513, Integrated Safety Analysis Guidance Document, and the American Institute of Chemical Engineers Guidelines for Hazard Evaluation Procedures for the preliminary ISA process methodology (AIChE, 1992). The What If/Checklist methodology is used for the preliminary ISA.
- From the preliminary ISA, unmitigated initiating events that could have an unacceptable risk ranking are identified as accidents of concern.
- The initiating events with an unacceptable risk ranking (accident of concern) are further analyzed in the preliminary ISA and this chapter, with the intent of identifying control measures, in particular mitigative engineered controls, to reduce the consequences to within acceptable values.
- An MHA and other postulated accidents that result in release of radioactive materials (fission products) into or outside of the HCF are analyzed in the PSAR. Other accidents that result in radiation exposure to individuals in the unrestricted area are also considered.
- Identify safety-related SSCs and ESFs and TS requirements that are required to mitigate the consequences of the accidents, such that the total effective dose equivalent (TEDE) to the maximally exposed individual outside of the controlled area of the site (site boundary) are calculated to be less than 1 rem.
- The MHA bounds all fission product release accident scenarios and is a non-credible hypothetical event.

Eden used the preliminary ISA (Appendix 13b) as a tool to identify selected accident scenarios in the HCF which are presented in this chapter. Eden's approach is informed by elements of 10 CFR Part 70 Subpart H.

13b.1.1 PROCESSES CONDUCTED OUTSIDE OF THE REACTOR FACILITY

The processes that are conducted in the HCF and analyzed under accident conditions are divided into three categories:

- Operations with SNM
- Radiochemical operations
- Operations with hazardous chemicals

The activities associated with each of these processes are described in more detail in Chapter 4b. A summary of the activities follows:

- Operations with SNM – Activities with SNM low-enriched uranium (LEU) containing no, or only small quantities of fission products, are conducted in the target fabrication area of the HCF. All SNM is stored in the HCF SNM storage area. The activities in the target fabrication area include:
  - SNM blending

- Oxide to metal reduction
- Ingot to foil production
- Foil to target production
- Final target assembly
- Storage of oxide, metal ingots, foils, and targets

- Radiochemical operations – Activities with irradiated targets are conducted in steel confinement boxes (SCBs) in the highly shielded target processing canyon of the HCF. These activities include:
  - Target receipt box (one box available):
    - Fresh target receipt in the target receipt box and sent to the transfer canal.
    - Irradiated target transfer from the transfer canal to the target receipt box.
    - Irradiated target inspection, quality control (QC) acceptance, preparation, and transfer to a dissolver box.
  - Dissolver box (four boxes available – six irradiated targets processed per box):
    - Irradiated target disassembly and LEU foil removal from cladding.
    - LEU foil placement in dissolver unit (up to six foils).
    - Dissolver unit vessel sealing.
    - Dissolver unit vessel evacuation and monitoring for leaks.
    - Addition of nitric acid (HNO_3) and [[ ]]$^{PROP/ECI}$ into dissolver unit vessel.
    - Irradiated target dissolution (six allowed per box per dissolver unit vessel).
    - Evacuation and capture of noble gases and halogens from dissolver unit vessel using the fission gas delay system (FGDS).
    - Molybdenum-99 (Mo-99) capture on titania column using the modified Cintichem process and product transfer to the purification box.
    - Uranyl nitrate ($UO_2(NO_3)_2$)/fission product solution transfer to uranium extraction (UREX) box.
  - Purification box (four boxes available):
    - Mo-99 purification using the modified Cintichem process.
    - Mo-99 product packaging and transfer to the packaging box.
    - Mo-99 product QC sample recovery and transfer to the packaging box.
    - Mo-99 purification waste processing and transfer to the waste packaging box.
  - Packaging box (four boxes available):
    - Mo-99 product preparation for shipping and transfer to the product shipping staging area.
    - Mo-99 product QC transfer to the QC metrology laboratory area.
    - LEU oxide (clean) transfer to the SNM storage area.

  - Process chemical kit transfer.
- UREX process box (two boxes available):
  - UREX processing of uranyl nitrate/fission product solution using tributyl phosphate (TBP) and dodecane to separate LEU from the solution.
  - Uranyl nitrate conversion to uranium (U) oxide.
- Waste packaging box (one box available):
  - Preparation and staging of waste for waste drum.
  - Transfer and grouting of liquid waste in waste drum.
  - Transfer of solid waste to waste drum.
  - Final preparation and closure of waste drum.
- Waste storage canyon:
  - Staging of waste drums on cart.
  - Lowering cart into the waste storage canyon for decay storage.
- QC metrology laboratory area:
  - Performance of QC on product radioisotopes.
- Product shipping area:
  - Preparation of Type B shipping container.
  - Product insertion with shield, and sealing and assembly of Type B shipping container.
  - Completion of QC and radiological inspections, shipping manifest, and placarding requirements.
- Waste shipping area:
  - Preparation of Type B shipping container.
  - Transfer of waste drums to Type B shipping container.
  - Sealing and assembly of Type B shipping container for shipment.
  - Completion of QC and radiological inspections, shipping manifest, and placarding requirements.

- Operations with Hazardous Chemicals – Activities are performed in the HCF with hazardous chemical solutions. Chemical solutions used for processing and purification are prepared outside of the HCF and outside of the EMIF. Limited quantities of chemicals are brought into the HCF as “kits” that are ready for use in the HCF. No chemical preparation work is performed in the HCF or EMIF.
  - Chemical kit transfer to the HCF staging area from outside of the EMIF.
  - Chemical kit transfer from the HCF staging area to the dissolver box.
  - Chemical kit transfer from the HCF staging area to the purification box.
  - Chemical kit transfer from the HCF staging area to the UREX box.
  - Chemical kit transfer from the HCF staging area to the target fabrication area.

13b.1.2 ACCIDENT INITIATING EVENTS

The process activities described in the previous subsection were considered in performing the preliminary ISA for identification of accident initiating events. Examples of event types that were used in the ISA include radiation protection failure, fire, potential releases/spills (gas or liquids), nuclear criticality, natural phenomena, and external events. Events were also categorized based on activity category. Accidents requiring further quantitative analysis were identified. These accidents were further categorized into the initiating events presented in the ISG Augmenting NUREG-1537. The preliminary ISA evaluated over 170 credible accident scenarios and identified the accident scenarios that posed a significant risk to the public, workers, or environment. Refer to Appendix 13b.A for a summary description of the preliminary ISA.

Table 13b.1-1 presents accident analysis categories as listed in the ISG Augmenting NUREG-1537. The table shows the corresponding ISA events that were selected for each category. Multiple events were evaluated for each accident category to ensure a comprehensive evaluation.

Table 13b.1-1
(Sheet 1 of 2)
Accident Initiating Events from ISA for Further Analysis

Accident Category	ISA Event
Criticality accidents	**Target processing canyon and waste storage canyon**
	DB-NC-001 – Nuclear criticality in dissolver box
	UP-NC-001 – Nuclear criticality in UREX process box
	WX-NC-001 – Nuclear criticality in cask loading bay
	SNM storage area
	SNMS-NC-001 – Nuclear criticality in SNM storage area
	Target fabrication area
	SNMB-NC-001 – Nuclear criticality in SNM blending area
	OMR-NC-001 – Nuclear criticality in oxide to metal reduction area
	IFP-NC-001 – Nuclear criticality in ingot to foil production area
	FTP-NC-001 – Nuclear criticality in foil to target production area
Loss of normal electrical power	DB-EE-001 – Loss of off-site electrical power during dissolver box activities
External events (meteorological, seismic, fire, flood)	TR-NP-001 – Seismic event – Target receipt box fails
	DB-NP-001 – Seismic event – Dissolver unit and box fails
	FG-NP-001 – Seismic event – FGDS fails
	UP-NP-001 – Seismic event – UREX process box fails
	WP-NP-001 – Seismic event – Waste packaging box fails
	WS-NP-001 – Seismic event – Waste drum transfer system fails
Critical equipment malfunction	DB-RS-003 – Dissolver unit ruptures during dissolver box activities
	DB-RS-004 – Dissolver unit seal leaks during dissolver box activities
	DB-RS-006 – Fission product solution leaks during transfer activities
	FG-RS-001 – FGDS ruptures
	FG-RS-002 – FGDS leak
	UP-RS-002 – UREX system ruptures during process box activities
	UP-RS-003 – UREX system seal leaks during process box activities
	UP-RS-004 – Raffinate solution leaks during transfer activities
	WP-RS-002 – Waste drum ruptures or leaks during waste packaging box activities
	WP-RS-003 – Raffinate solution leaks or spills during waste packaging operations

Table 13b.1-1
(Sheet 2 of 2)
Accident Initiating Events from ISA for Further Analysis

Accident Category	ISA Event
Operator error	DB-RS-005 – Dissolver unit not evacuated following dissolution process
	FG-RS-003 – FGDS inadvertently purged
	WS-RS-001 – Waste drum ruptures or leaks during transfer due to dropping
Facility fire	DB-FI-001 – Fire due to combustible materials or electrical short in dissolver box
	DB-FI-002 – Fire spreads to dissolver box
	DB-FI-003 – U foil ignites during target disassembly
	UP-FI-001 – Fire due to combustible materials, flammable materials, or electrical short in UREX process box
	UP-FI-002 – Fire spreads to UREX process box
	UP-FI-003 – Fire/explosion from formation of red oil in TBP/dodecane
	WP-FI-001 – Fire due to combustible materials or electrical short in waste packaging box
	WP-FI-002 – Fire spreads to waste packaging box
	WS-FI-001 – Fire due to combustible materials or electrical short in waste storage canyon
	WS-FI-002 – Fire spreads to waste storage canyon
Chemical release events	DB-RS-001 – Nitric acid solution spill in dissolver box
	PB-RS-001 – Chemical solution spill in purification box
	PX-RS-001 – Chemical solution spill in packaging box or during transfer to the HCF high bay
	UP-RS-001 – Chemical solution spill in UREX process box
	WP-RS-001 – Chemical solution spill in waste packaging box

Abbreviations: ISA = Integrated Safety Analysis | UREX = uranium extraction | SNM = special nuclear material | FGDS = fission gas delay system | TBP = tributyl phosphate | HCF = Hot Cell Facility

13b.2 ANALYSIS OF ACCIDENTS WITH RADIOLOGICAL CONSEQUENCES

The purpose of this section of the PSAR is to discuss the MHA and credible bounding accident conditions that could result in a release of radioactive material into or outside of the radiological/restricted areas of the HCF. The initial step is to establish the radioactive material at risk (MAR) and the corresponding source term (ST). Because the irradiated target fission product and actinide inventory make up the MAR in the HCF, the downwind dose analysis methodology used for the RF is applicable for the HCF. The difference in the radionuclide inventory is that some decay time (4 – 6 hours [hr.]) has elapsed prior to the start of the target disassembly and dissolution processes in the target processing canyon. The delay time is required for several reasons, including decay of the short-lived fission products allowing for a more manageable dose burden to the HCF workers and HCF equipment and shield windows. From a Mo-99 product purity perspective, several hours of decay are required to ensure that the evolution of radioactive iodine is complete before the dissolution process begins.

All the irradiated target processing activities in the HCF are performed either in the transfer canal or within SCBs in the target processing canyon. As described in Chapter 4b and summarized in Subsection 13b.2.1, redundant and different SCBs are used to perform the target disassembly and dissolution, purification, and waste packaging and staging activities in the target processing canyon. Administrative limits are placed on the number of irradiated targets that are processed in a dissolver vessel per dissolver box.

For each accident identified for further evaluation, an accident scenario, or multiple scenarios, are developed that would cause the MAR to be available for release into an SCB, the ventilation filtration system, and ultimately the environment. Initial conditions are established along with assumptions in defining the ST for release. A consequence analysis is presented with a probability classification. A summary of safety-related SSCs and TS is included for each accident scenario.

The accident dose criterion adopted by Eden for the radiation dose to an individual member of the public is 1.0 rem, TEDE to the whole body. This is applied at the 500-meter (m) (1640-foot [ft.]) site boundary or, alternatively, at the maximum dose exposure distance from the facility for a member of the public. For the occupational worker, the TEDE dose limit is 5 rem, or 50 rem committed dose equivalent to any individual organ or tissue other than the lens of the eye. These dose limits are established by 10 CFR 50.34(a)(1)(i); 10 CRF 20.1301; and 10 CFR 20.1201.

The calculated mitigated dose to an individual member of the public at the 500-m (1640-ft.) site boundary, or the maximum exposure distance, for the MHA or any other postulated accident must be less than 1.0 rem (TEDE) to be within the accident dose criterion. If the dose is found to be greater than this value, additional controls, SSCs, or ESFs must be incorporated into the facility design bases. Even if calculations show that safety-related SSCs, ESFs, or both are not needed to maintain public doses within the accident dose criterion, the design may incorporate additional SSCs to provide defense-in-depth and maintain accident doses As Low As Reasonably Achievable (ALARA). The TEDE includes the dose due to both immersion and inhalation. Ingestion is not included because there are no crops, farms, dairies, or watersheds near the site boundary. The immersion dose includes direct exposure to the individual as the radioactive cloud, or plume, immerses and passes by the individual. The inhalation dose includes the dose from radioisotopes inhaled from the cloud as it passes by the individual. The inhalation dose includes direct exposure from the material while in the lungs and the 50-year committed dose from material remaining in the lungs or passing into the body organs.

The calculated dose to an occupational worker includes the direct exposure and committed inhalation dose to a worker within the HCF high bay during the accident and release of radionuclides into the SCB. It is assumed that the occupational worker responds to radiation alarms in the HCF high bay and exits the area within a defined time period.

The cumulative airborne releases of radionuclides to the environment were developed from single isotope release calculations from the release point under evaluation. The downwind dose estimates were developed using standard Gaussian-plume dispersion models (Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessment at Nuclear Power Plants, Revision 1) for air transport and derivation χ/Q (atmospheric dispersion coefficient) values (see Subsection 2.3.4), ORIGEN-2.2 Isotope Generation and Depletion Code (Croff, 1980), and immersion and inhalation dose conversion factors (DCFs) (USEPA, 1988; USEPA, 1993). Combining doses for the individual isotopes released at the distance of interest provides the TEDE estimate for a member of the public.

The downwind dose calculations use a simple conservative approach. An F stability, 1 m/second (s) (3.3 ft/s) wind speed was chosen for the analysis, which represents a conservative bound on the downwind dose. A ground release and an HCF stack height of 15 m (49.2 ft.) were used in the analysis. No building wake effects, exhaust velocity, or surface roughness effects are used in the analysis. The results of the analysis are presented in the following subsections in more detail.

13b.2.1 SOURCE TERM EVALUATION

The quantity of airborne radionuclides that leave the HCF in the event of a postulated accident is referred to as the source term (ST). The ST quantity is specific to a given accident. For a given postulated accident in the HCF, the ST for each radionuclide is as follows:

$$ST_i = MAR_i \times MRF_i \times LPF_i \qquad \text{(Equation 13b.2-1)}$$

where:

ST_i is the ST for the specific radionuclide *i* leaving the stack in units of activity

MAR_i is the MAR for the radionuclide *i*, in units of activity

MRF_i is the matrix release fraction (MRF) for the radionuclide *i*

LPF_i is the Leak Path Fraction (LPF) for the radionuclide *i*

The ST is calculated for each radionuclide, the sum of which makes up the total ST inventory. The sum of the ST_i values represents the total amount of radionuclide activity released through the release pathway under consideration. For accidents involving target dissolution, the fission product radionuclide inventory and actinide inventory make up the total MAR.

13b.2.1.1 Matrix Release Fraction

For a target, the U metal foil and the aluminum (Al) cladding are the two primary barriers that prevent the release of fission products into the pool, transfer canal, and target receipt box. For operations in these areas, the effectiveness of the barriers in retaining the fission products is assumed to be 100 percent. In the dissolver box, the targets are disassembled, and the U foil is placed in the dissolver vessel for processing. During dissolution, the barriers maintaining the

radionuclides are the dissolver vessel and subcomponents of the dissolver unit. Under postulated accident conditions, these barriers could be challenged, allowing fission products and actinides to be released into the dissolver box. Other accidents are specific to the FGDS and the UREX box.

The MRF for a specific radionuclide is defined as the fraction of the inventory that is inadvertently released into an SCB following a postulated accident. For the target processing activities, four bounding types of accident conditions could exist that could jeopardize the integrity of the barriers:

- A component of the dissolver vessel is breached during or after dissolution of the U foils.
- A component of the FGDS is breached.
- An iodine trap is breached.
- A component of the UREX system is breached.

For all four of these types of accidents the MRF is assumed to be 1.0 unless otherwise specified in an accident scenario.

13b.2.1.2 Leak Path Fraction

The LPF is the fraction of noble gas, halogen, other fission product, or actinide radionuclide inventory in a SCB from a postulated accident that is released to the environment through the HCF ventilation system. Every SCB maintains high efficiency particulate air (HEPA) and charcoal filters for defense-in-depth. Every SCB is controlled to maintain a negative pressure and flow rate to the HCF exhaust ventilation system. In the HCF mechanical equipment room, redundant HEPA and charcoal filters are used to ensure the exhaust from the confinement boxes is filtered as described in Section 6b.2 and Subsection 9b.1.1

The LPF values for the noble gases, halogens, and other radionuclides are shown in Table 13b.2-1. For this analysis, it is assumed that there is no filtering, retention, or delay of noble gases that are released to a SCB during a postulated accident (LPF = 1.0). The noble gas radionuclides that are released to a SCB or the target processing canyon are assumed to be immediately transported to the HCF ventilation system and released to the environment though the stack or as a ground release.

It is assumed that the decontamination factor for the halogens is 1000 (LPF = 0.001) (ANSI/ASME, 2002). Charcoal filter systems are found to be effective in removing halogens from an exhaust stream. These types of filters are commercially available and can be tested for effectiveness. Although charcoal filters are also be used within each confinement box for defense-in-depth, no credit is taken for these filters because they cannot be tested in-situ for effectiveness. The charcoal filters that are credited are those in the HCF mechanical equipment room.

It is assumed that the decontamination factor of the other fission products and actinides is 3333 (LPF = 0.0003) (DOE, 2003). HEPA filter systems are found to be effective in removing micron particle sizes from an exhaust stream. These types of filters are commercially available and can be tested for effectiveness. HEPA filters are in the HCF mechanical equipment room.

13b.2.2 DOSE CALCULATIONS

Dose calculations to members of the public at the site boundary and occupational workers for an accident involving the airborne release of radioactive materials are performed by using the radionuclide ST and dose factor (DF) for the specific radionuclide. The TEDE is the effective whole-body dose to a member of the public at the site boundary or maximum exposure distance or to an occupational worker in the HCF high bay. The TEDE is derived by multiplying the ST by the DF and includes dose exposure from both immersion and inhalation. Values for the inhalation effective DCF (coefficient), committed effective dose equivalent (CEDE), and the immersion effective DCF (coefficient), cloudshine effective dose equivalent (CSDE), can be used from a number of sources. For this analysis, the Federal Guidance Report No. 11 (USEPA, 1988) is used for the inhalation effective dose coefficients and the Federal Guidance Report No. 12 (USEPA, 1993) is used for the immersion effective dose coefficients.

For this analysis, the TEDE includes the dose due to immersion and inhalation. Ingestion is not included because there are no crops, farms, dairies, or watersheds within the area of the site boundary. The immersion dose includes direct exposure to the individual as the radioactive cloud, or plume, immerses and passes by the individual. The inhalation dose includes the dose from radioisotopes inhaled from the cloud as it passes by the individual. The inhalation dose includes direct exposure from the material while in the lung and the 50-year committed dose from material remaining in the lung or passing into the body organs.

The TEDE value for each radionuclide was calculated using the ST and the DF formulas. Radionuclide decay periods of 4 hr. and 6 hr. were used to account for the target decay before processing. A decay period of 4 hr. represents the shortest decay time after which target disassembly and dissolution can begin. A decay period of 6 hr. represents the time at which the dissolution of the U foils is completed. The TEDE values were calculated on a per kilowatt thermal (kWt) basis. The following factors were used to generate the TEDE values:

MRF = 1.0 for all radionuclides, can be modified for specific accidents

LPF = 1.0 for noble gases, 0.001 for halogens, 0.0003 all other chemical groups

χ/Q (stack release at 600 m [1969 ft.]) = 0.000407 s per cubic meter (m^3) for a 15-m stack, F stability, 1 m/s wind speed

Finite cloud correction factor (FCCF) (600 m) = 0.111

χ/Q (ground release at 500 m [1640 ft.]) = 0.00191 s/m^3, F stability, 1 m/s wind speed

FCCF (500 m) = 0.096

χ/Q (stack release at 2500 m [1.6 miles {mi.}]) = 0.000135 s/m^3 for F stability, 1 m/s wind speed

χ/Q (ground release at 2500 m [1.6 mi.]) = 0.000169 s/m^3 for F stability, 1 m/s wind speed

FCCF (2500 m [1.6 mi.]) = 0.307

Respiratory rate (RR) = 3.3E-4 m^3/s

$CEDE_i$ = Federal Guidance Report No. 12, Table 2.1, Effective Committed Dose for Inhalation (USEPA, 1993)

$CSDE_i$ = Federal Guidance Report No. 11, Table III.1, Effective Dose for Air Submersion (USEPA, 1988)

The results for the TEDE for each radionuclide can be summed for the chemical group types. Table 13b.2-2 shows the TEDE sum for each group and the fraction of the dose contributed by each group. The total downwind dose for the 25-day target irradiation is 6.07E-4 rem/kWt for a 4-hr. decay, and 5.15E-4 rem/kWt for a 6-hr. decay.

The main radionuclides contributing to the downwind dose (for noble gases and halogens) can be identified. The radionuclides, their half-lives, and their percentage contribution to the total noble gas and halogen downwind dose for a 25-day irradiation and 6-hr decay are as follows:

Noble Gases

Krypton-87 (Kr-87) (1.27 hr.) = 1.7 percent

Krypton-88 (Kr-88) (2.84 hr.) = 35.2 percent

Xenon-133 (Xe-133) (5.24 days) = 4.0 percent

Xenon-135 (Xe-135) (9.10 hr.) = 13.1 percent

Xenon-135 metastable (Xe-135m) (15.3 minutes) = 4.5 percent

Halogens

Iodine-131 (I-131) (8.04 days) = 26.8 percent

Iodine-133 (I-133) (20.8 hr.) = 11.0 percent

Iodine-135 (I-135) (6.57 hr.) = 1.5 percent

All other noble gases and halogens contribute less than 2.2 percent combined to the total noble gas and halogen downwind dose. Of these, the most important noble gas radionuclide is Kr-88, followed by Xe-135. The most important halogen radionuclide is I-131, followed by I-133. No bromine (Br) isotopes contribute significantly to the downwind dose.

For the other fission products, cerium-144, yttrium-91, and tellurium-132 are the most important radionuclides, contributing 25.0 percent, 15.0 percent, and 7.9 percent, respectively, to the total other fission products downwind dose. Neptunium-239 dominates the actinide downwind dose, contributing 36.8 percent.

For the occupational worker dose during an accident involving target disassembly, dissolution, or processing, it is assumed that the worker is at the manipulator station in front of a shield window when the accident occurs. Because the accidents all occur within the shielded target processing canyon and negative pressures are maintained in the SCBs and the canyon area, the worker does not receive any dose from the accidents.

13b.2.3 ACCIDENT EVALUATION

Selected accidents were identified to be further analyzed in more detail to determine preventative/mitigative features and the potential doses to the occupational worker and member of the public at the site boundary. Table 13b.2-3 presents the accidents analyzed and their analysis location in the chapter. These accidents represent bounding conditions and may envelope several other different accident conditions. For each accident identified, accident scenarios are developed that could act as the initiator or multiple initiators for the accident. In the accident scenario development, preventative and mitigative features and conditions are identified and analyzed that would prevent or mitigate the accident progression and the release of radioactive material from the HCF.

13b.2.3.1 Maximum Hypothetical Accident

NUREG-1537 describes the MHA as a limiting event that is not expected to occur, and for which the scenario may not be entirely credible. The initiating event and the scenario details need not be analyzed, but the potential consequences should be analyzed and evaluated. The MHA selected should bound all credible potential accidents at the facility yet should be an event that is not likely to occur during the life of the facility.

The MHA analyzed for the HCF is a fire in a dissolver box containing both iodine traps and the FGDS. A fire is assumed to occur from the ignition of combustibles inadvertently placed in the dissolver box. The iodine traps and FGDS are assumed to be exposed to the fire, releasing the inventory of iodine and noble gases into the dissolver box.

MHA – Fire due to combustible materials or electrical short in a dissolver box (DB-FI-001) – releases iodine and noble gases

This MHA represents the bounding consequence scenario for the release of iodine and noble gases from the HCF target processing canyon. The four dissolver boxes and two research and development (R&D) boxes are ventilated through HCF ventilation Zone 1a. As described in Subsection 9b.1.1 and Section 6b.2, HCF Zone 1a maintains the most negative pressure of the zones because the activities in boxes (SCBs 2 – 7) include dissolution of the irradiated U foils and contain the largest inventory of MAR. HCF Zone 1a is filtered through HEPA and charcoal filters, as described in Subsection 9b.1.1 and Section 6b.2. The charcoal filters have a decontamination factor of 1000 for removing the halogens, as described in Subsection 13b.2.1.2. The noble gases are released with no decontamination factor.

Scenario Development

During the target dissolution process using nitric acid, halogens (iodine and Br) evolve from the solution and are captured in an iodine trap after the dissolution process is completed. The iodine trap is a small (approximately 10 cubic centimeters [0.61 cubic inches {in^3}] internal volume) metal container with valves on each end and filled with copper shavings. During evacuation of the dissolver vessel using the FGDS, iodine enters the trap and forms copper iodide. The iodine trap is a single use container that is attached to the FGDS and dissolver unit as part of the dissolution preparation activities. After the dissolution process and evacuation of the unit, the iodine trap valves are closed, and the trap is removed from the FGDS and the dissolution unit. The iodine trap is staged in the dissolver box for decay.

The radionuclides present in the iodine trap after several days of decay are I-131 with an 8.04-day half-life. In five half-lives (40.2 days) the radionuclide inventory has decreased to about 3 percent of the original inventory.

I-131 is a medical radioisotope that can be processed and packaged for sale from the HCF. However, it is expected that the demand for I-131 is significantly less than the amount produced in the fission process. Most of the iodine traps are staged for decay and then included in the radioactive waste stream.

Combustible materials used in a dissolver box are limited. For this MHA, it is assumed that flammable solids or liquids are inadvertently placed in a dissolver box and ignite. It is assumed that iodine traps from six weeks of processing (12 iodine traps) and the FGDS are exposed to the fire, releasing the inventory of iodine and noble gases into the box and ultimately to the

outside environment through the HCF Zone 1a ventilation system, which assumes a LPF of 1.0 for the noble gases and 0.001 for the iodine.

The radioactive iodine and noble gas inventory available for release represents the quantity accumulated from processing. For this scenario, the bounding assumption limits the number of irradiated targets that can be processed in a dissolver box to 6 per day and 12 per week.

Consequence Analysis

The downwind dose to a member of the public can be calculated using Table 13b.2-2. The MRF for the halogens and noble gases is assumed to be 1.0. The results are as follows for the noble gases and halogens.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 2.01E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0362\ rem$$

$$noble\ gases\ (30\ hr\ decay) \Rightarrow\ 1.94E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0035\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 1.34E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0241\ rem$$

$$halogens\ (30\ hr\ decay) \Rightarrow\ 9.93E-3\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0179\ rem$$

$$halogens\ (7d+6\ hr\ decay) \Rightarrow\ 4.86E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0087\ rem$$

$$halogens\ (8d+6\ hr\ decay) \Rightarrow\ 4.46E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0080\ rem$$

$$halogens\ (14d+6\ hr\ decay) \Rightarrow\ 2.66E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0048\ rem$$

$$halogens\ (15d+6\ hr\ decay) \Rightarrow\ 2.44E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0044\ rem$$

$$halogens\ (21d+6\ hr\ decay) \Rightarrow\ 1.45E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0026\ rem$$

$$halogens\ (22d+6\ hr\ decay) \Rightarrow\ 1.33E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0024\ rem$$

$$halogens\ (28d+6\ hr\ decay) \Rightarrow\ 7.95E-6\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0014\ rem$$

$$halogens\ (29d+6\ hr\ decay) \Rightarrow\ 7.29E-6\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0013\ rem$$

$$halogens\ (35d + 6\ hr\ decay) \Rightarrow\ 4.35E-6 \frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0008\ rem$$

$$halogens\ (36d + 6\ hr\ decay) \Rightarrow\ 3.99E-6 \frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0007\ rem$$

$Total\ noble\ gases\ \Rightarrow\ 0.0397\ rem$

$Total\ halogens\ \Rightarrow\ 0.0771\ rem$

$other\ fission\ products \Rightarrow\ 0.00\ rem$

$actinides \Rightarrow 0.00\ rem$

$Total\ \Rightarrow\ 0.117\ rem$

Ground release at 500 m (1640 ft.):

$Total\ noble\ gases\ \Rightarrow\ 0.161\ rem$

$Total\ halogens\ \Rightarrow\ 0.363\ rem$

$other\ fission\ products \Rightarrow\ 0.00\ rem$

$actinides \Rightarrow 0.00\ rem$

$Total \Rightarrow\ 0.524\ rem$

Note that the six most recent iodine traps represent approximately 90 percent of the iodine dose and that for the noble gases the downwind dose diminishes to negligible quantities after 30 hr. of decay.

A TEDE of 117 millirem (mrem) for a stack release and 524 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

At 2500 m (1.6 mi.) (i.e., closer than the nearest resident), assuming that the wind is blowing in a west-northwest direction from the HCF, a TEDE of 62 mrem for a stack release and 78 mrem for a ground release are calculated. The prevailing wind direction at the EIPC site is from the south.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- HCF ventilation system Zone 1a is a safety-related structure, system, or component (SSC) and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.

- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.
- The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.

13b.2.3.2 Loss of Normal Electrical Power

The electrical power systems are described in Chapter 8. There are no accidents identified for the HCF from a loss of normal electrical power that are accident initiating events.

Loss of electrical power during dissolver box activities (DB-EE-001)

During the target U foil dissolution process activity in a dissolver box, the electrical power is lost in the HCF. Loss of electrical power is considered a not unlikely event.

Scenario Development

Electrical power to the HCF includes normal off-site electrical power from the grid, backup electrical power using standby diesel generators, and safety-related electrical power using an uninterruptible power supply system (UPSS). During normal operations, the HCF electrical systems are provided power from off-site electrical power. If off-site electrical power is lost, standby diesel generators are used to complete process activities in the HCF by providing electrical power to the HCF ventilation system and other required systems. The UPSS provides electrical power to the HCF Zone 1a ventilation system if standby diesel generator power cannot be provided.

Off-site electrical power could be lost to the HCF during target U foil dissolution or other isotope processing activities. The HCF ventilation system is required to be operating during processing activities in the target processing canyon. Standy diesel generators are used to provide backup electrical power to selected systems in the HCF, including the HCF ventilation system, to complete process activities during off-site power outages. For all activities performed in the HCF during an electrical power outage with no backup power, operators place the work in a safe condition.

The only activity where a significant quantity of fission products are at risk with a loss of electrical power is during the target U foil dissolution process in a dissolver box. Target dissolution is expected to take approximately 2 hr. to complete. The dissolution unit and dissolution process are described in Chapter 4b. Upon introduction of the nitric acid solution into the dissolution unit, U foil dissolution continues until the U foils are all dissolved or the acid concentration is decreased. The HCF Zone 1a is required to be operating during the dissolution process to ensure that, if an accident does occur within the dissolver box during the dissolution process, the noble gases, halogens, and other volatile fission products are exhausted through the HEPA and charcoal filters in HCF Zone 1a. Therefore, the Zone 1a portion of the HCF ventilation system is a safety-related SSC/ESF and is backed by a safety-related SSC/ESF UPSS.

Consequence Analysis

There are no consequences for the loss of electrical power at the HCF.

Technical Specification Considerations

- HCF ventilation system Zone 1a is a safety-related SSC/ESF.
- HCF Zone 1a requires a safety-related SSC/ESF UPSS to provide electrical power to the HCF Zone 1a components during dissolution operations in SCBs 2 – 7.

13b.2.3.3 External Events

Seismic event breaches fission gas delay system (FG-NP-001)

A seismic event causes a failure in the FGDS, breaching the staging decay volume boundary and releasing the noble gas contents into the SCB. A seismic event causing failure of the FGDS is a highly unlikely event.

Scenario Development

During the target dissolution process using nitric acid, noble gases (Xe and krypton) evolve from the solution as the U foils are dissolved. The noble gases are captured in the free volume of the sealed dissolver unit until the U foil dissolution is complete. This process takes approximately 2 hr.

After the dissolution is complete, the noble gases are evacuated from the dissolution unit vessel using sorption pumps in the FGDS within the dissolver box. The system is made up of multiple sorption pumps that are valved off after the evacuation and staged for decay. The purpose of the system is to retain the noble gas radionuclides until the main downwind dose contributors (Kr-88, 2.84 hr. half-life; Xe-135, 9.10 hr. half-life; and Xe-133, 5.24 day half-life) have decayed sufficiently to allow for release to the environment. The gas volume from one batch of six targets is staged for decay for at least 10 days. At that time, only the Xe-133 and krypton-85 (Kr-85) remain as radionuclides in the gas. An individual FGDS is in each of the dissolver boxes.

Xe-133 is a medical radioisotope that can be processed and packaged for sale in the HCF. However, it is expected that the demand of Xe-133 is significantly less than the amount produced in the fission process. Most of the Xe-133 is allowed to decay in the FGDS and then released to the environment through the HCF Zone 1a exhaust stack. Xe-133 intended for sale is evacuated into a Xe cold trap after the dissolution process. The trap is staged for decay. After several days of decay, it is moved to a purification box or R&D box for further processing and packaging for shipping.

This event assumes that immediately after processing and evacuation of the dissolver unit into the FGDS, a seismic event occurs that causes components to fail in the system. releasing all the contents of the system to the dissolver box. The noble gas inventory for six irradiated targets (30 kWt each) from the day's operation (decayed 6 hr.) and six irradiated targets from the previous day's operation (decayed 30 hr.) are assumed to be released through the HCF Zone 1a exhaust stack without any additional filtration or retention.

Consequence Analysis

The noble gas radionuclides from six irradiated targets (30 kWt each) decayed 6 hr., and the noble gas radionuclides from six irradiated targets decayed 30 hr. (from the previous day's operation), are released into the dissolver box. The ST from the release of the noble gases staged in the FGDS for more than the preceding 30 hr. are negligible and is not included in the

analysis. The downwind dose to a member of the public is calculated using an LPF for the noble gases of 1.0. The MRF for the noble gases is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 2.01E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0362\ rem$$

$$noble\ gases\ (30\ hr\ decay) \Rightarrow\ 1.94E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0035\ rem$$

$$Total \Rightarrow\ 0.0397\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.147\ rem$$

$$noble\ gases\ (30\ hr\ decay) \Rightarrow\ 7.87E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.014\ rem$$

$$Total \Rightarrow\ 0.161\ rem$$

A TEDE of 40 mrem for a stack release and 161 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.

13b.2.3.4 Critical Equipment Malfunction

1 – Dissolver unit ruptures during dissolver box activities (DB-RS-003)

During the target dissolution process activity, the dissolver vessel has a significant leak or rupture, spilling its contents into the dissolver box. A dissolver vessel leak or rupture is considered an unlikely event.

Scenario Development

During the target dissolution process using nitric acid, the dissolver unit has a significant leak or rupture, spilling its contents into the dissolver box. Initiating events include the following:

- Dissolver vessel overpressurizes due to loss of cooling and the dissolution system pressure control valve fails to open.
- Dissolver vessel overpressurizes due to runaway nitrogen oxide (NO_x) gas production and the dissolution system pressure control valve fails to open.

- Nitric acid corrosion compromises the structural integrity of the dissolver vessel and remains undetected.

The dissolver unit is fabricated from stainless steel and the system is designed, tested, and rated to twice the maximum allowable working pressure (MAWP). A pressure control valve on the gaseous side of the dissolver vessel system allows for gases and liquids to be captured in a separate reserve vessel in the dissolver box if the dissolver vessel pressure exceeds the MAWP setting. The dissolver unit operating pressure is not expected to exceed the MAWP during normal operations. The dissolver vessel could corrode over time due to the hot nitric acid. Both 304 and 316 type stainless steels are very corrosion resistant to nitric acid. The dissolution system undergoes preoperational inspections and performance testing to ensure system integrity prior to the dissolution activity. The dissolution system is leak checked to ensure there are no system leaks prior to the dissolution activity.

This accident is bounding for other events where leaks could occur in the dissolution system due to equipment malfunction or operator errors.

Consequence Analysis

The dissolver unit is designed to process up to six irradiated target U foils. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay and that all the U foils have been dissolved in the nitric acid when the event occurs. The dissolver unit is assumed to be breached, spilling the contents of the vessel in the dissolver box. All the noble gases, halogens, other fission products, and actinides are assumed to be released into the dissolver box.

The noble gas, halogen, other fission product, and actinide inventory from six irradiated targets (30 kWt each) decayed 6 hr. is released into the dissolver box. The downwind dose to a member of the public can be calculated using an LPF for the noble gases of 1.0; halogens, 0.001; other fission products, 0.0003; and actinides, 0.0003. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 2.01E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0362\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 1.34E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0241\ rem$$

$$other\ fp\ (6\ hr\ decay) \Rightarrow\ 1.62E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0291\ rem$$

$$actinides\ (6\ hr\ decay) \Rightarrow\ 1.79E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0032\ rem$$

$$Total \Rightarrow\ 0.093\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.147\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 6.29E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.113\ rem$$

$$other\ fp\ (6\ hr\ decay) \Rightarrow\ 7.61E-4 \frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.137\ rem$$

$$actinides\ (6\ hr\ decay) \Rightarrow\ 8.39E-5 \frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0151\ rem$$

$$Total \Rightarrow\ 0.412\ rem$$

A TEDE of 93 mrem for a stack release and 412 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- A pressure control valve and reserve tank are required for a dissolution operation in a dissolver box.
- The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.
- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

2 – Dissolver unit seal leaks during dissolver box activities (DB-RS-004)

During the target dissolution process activity, the dissolver vessel has a seal leak, allowing the noble gas and halogen inventory to be released into the dissolver box. A dissolver vessel seal leak is considered an unlikely event.

Scenario Development

During the target dissolution process activity, the dissolver vessel has a seal leak, allowing the noble gas and halogen inventory to be released into the dissolver box. Initiating events include the following:

- Dissolution system is not properly sealed during dissolver system preparation, and a leak is not detected during the pre-dissolution inspection and performance test.
- Dissolution system develops a leak during the dissolution process for some undetermined reason.

Several components of a target dissolution system are single use and are replaced after every dissolution. This includes the iodine trap and other hardware. Other connections are detached after processing and re-attached prior to use, including the connections associated with the FGDS. The lid of the dissolver vessel is opened after every use to place irradiated target foils in

a basket within the unit. The lid seal and lid are then re-attached to the dissolver vessel. After all the preparation activities are completed, the dissolution system is evacuated and checked for leaks by ensuring that the vacuum holds for a designated period.

This accident is bounding for other events where gas leaks could occur in the dissolution system due to equipment malfunction or operator errors.

Consequence Analysis

The dissolver unit is designed to process up to six targets. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay and that all the U foils have been dissolved in the nitric acid when the event occurs. The dissolver unit is assumed to leak in the free space region of the dissolver unit, releasing the noble gases and halogens into the dissolver box. All the noble gases and halogens are assumed to be released into the dissolver box.

The noble gas and halogen inventory from six irradiated targets (30 kWt each) decayed 6 hr. are released into the dissolver box. The downwind dose to a member of the public can be calculated using an LPF for the noble gases of 1.0 and halogens, 0.001. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 2.01E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0362\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 1.34E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0241\ rem$$

$$other\ fission\ products\ \Rightarrow\ 0.00\ rem$$

$$actinides \Rightarrow\ 0.00\ rem$$

$$Total \Rightarrow\ 0.060\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 8.16E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.147\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 6.29E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.113\ rem$$

$$other\ fission\ products\ \Rightarrow\ 0.00\ rem$$

$$actinides \Rightarrow\ 0.00\ rem$$

$$Total \Rightarrow\ 0.260\ rem$$

A TEDE of 60 mrem for a stack release and 260 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.
- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

3 – Fission gas delay system ruptures (FG-RS-001)

During operation of the FGDS, an integral component on the system fails allowing the noble gas inventory and halogens to be released into the dissolver box. A component failure of the FGDS is considered an unlikely event.

Scenario Development

During the target dissolution process using nitric acid, noble gases and halogens evolve from the solution as the U foils are dissolved. The noble gases and halogens are captured in the free volume of the sealed dissolver unit until the U foil dissolution is complete. This process takes approximately 2 hr.

After the dissolution is complete, the noble gases and halogens are evacuated using the FGDS within the dissolver box. The system is made up of a sorption pump and an iodine trap. The purpose of the system is to capture the halogens and retain the noble gas radionuclides until the main downwind dose contributors (Kr-88, 2.84 hr. half-life; Xe-135, 9.10 hr. half-life; and Xe-133, 5.24 day half-life) have decayed sufficiently to allow for release to the environment. The gas volume from one batch of six targets is staged for decay for at least 10 days. At that time, only the Xe-133 and Kr-85 remain as radionuclides in the gas. The system is comprised of multiple sorption pumps. An individual FGDS is provided in each of the dissolver boxes.

Both I-131 and Xe-133 are medical radioisotopes that can be processed and packaged for sale from the HCF. However, it is expected that the demand is significantly less than the amount produced in the fission process. The Xe-133 is allowed to decay in the FGDS and then released to the environment through the HCF Zone 1a exhaust stack. The iodine trap is removed from the system and staged in the dissolver box for decay and later processing or becomes part of the waste stream. Xe-133 intended for sale is evacuated into a Xe cold trap after the dissolution process. The trap is staged in the dissolver box for decay. After several days of decay, the iodine trap or the Xe cold trap is moved to a purification box or R&D box for further processing and packaging for shipping.

This event assumes that immediately after processing and during evacuation of the dissolver unit into the FGDS a component of the system fails, releasing all the noble gas and halogen

inventory into the dissolver box. The noble gas and halogen inventory for six irradiated targets (30 kWt each) decayed 6 hr. is assumed to be released into the dissolver box.

This accident is bounding for other events where the noble gases and halogens are released by failure of a component in the FGDS or an operator error while using the FGDS.

Consequence Analysis

The consequences for this accident are the same as for the previous dissolver unit seal leak. The dissolver unit is designed to process up to six targets. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay during the evacuation process of the dissolver unit using the FGDS. All the noble gases and halogens are assumed to be released into the dissolver box.

The noble gas and halogen inventory from six irradiated targets (30 kWt each) decayed 6 hr. are released into the dissolver box. The downwind dose to a member of the public can be calculated using an LPF for the noble gases of 1.0 and for halogens, 0.001. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow 2.01E-4\frac{rem}{kW} \times 1.0 \times 30\ kW \times 6\ targets = 0.0362\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow 1.34E-4\frac{rem}{kW} \times 1.0 \times 30\ kW \times 6\ targets = 0.0241\ rem$$

$$other\ fission\ products \Rightarrow 0.00\ rem$$

$$actinides \Rightarrow 0.00\ rem$$

$$Total \Rightarrow 0.060\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow 8.16E-4\frac{rem}{kW} \times 1.0 \times 30\ kW \times 6\ targets = 0.147\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow 6.29E-4\frac{rem}{kW} \times 1.0 \times 30\ kW \times 6\ targets = 0.113\ rem$$

$$other\ fission\ products \Rightarrow 0.00\ rem$$

$$actinides \Rightarrow 0.00\ rem$$

$$Total \Rightarrow 0.260\ rem$$

A TEDE of 60 mrem for a stack release and 260 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.
- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

13b.2.3.5 Operator Error

Dissolver unit not evacuated following dissolution process (DB-RS-005)

After target dissolution, the dissolver unit is not evacuated properly to the FGDS, allowing the noble gas and halogen inventory to be released into the dissolver box. An operator error involving the dissolver vessel is considered an unlikely event.

Scenario Development

The dissolver unit is evacuated before the U and fission product solution is pumped through the titania column to remove the Mo-99. This evacuation process ensures that the noble gases and halogens in the dissolver unit are removed prior to the solution transfer. This accident assumes that the operator inadvertently skips these procedural steps and pumps the solution through the titania column with the release of the noble gases and halogens to the dissolver box. The quantity of noble gases that are present in a target after a 21-day irradiation is 0.00074 gram-moles (g-mols) (1.63E-6 pound-moles [lb-mols]). For six irradiated targets, this is 0.0044 g-mols (9.7E-6 lb-mols) of gas. In a volume of 1 liter (L) (0.26 gallons [gal.]), the pressure from the noble gases is about 0.01 megapascal (1.5 pounds per square inch) at 20 degrees Celsius (°C) (68 degrees Fahrenheit [°F]).

Consequence Analysis

The consequences for this accident are the same as for the previous dissolver unit seal leak. The dissolver unit is designed to process up to six targets. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay during the evacuation process of the dissolver unit using the FGDS. All the noble gases and halogens are assumed to be released into the dissolver box.

The noble gas and halogen inventory from six irradiated targets (30 kWt each) decayed 6 hr. are released into the dissolver box. The downwind dose to a member of the public can be calculated using an LPF for the noble gases of 1.0 and for halogens, 0.001. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 2.01E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0362\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 1.34E-4\frac{rem}{kW}\ \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0241\ rem$$

$$other\ fission\ products\ \Rightarrow\ 0.00\ rem$$

$$actinides \Rightarrow\ 0.00\ rem$$

$$Total \Rightarrow\ 0.060\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (6\ hr\ decay) \Rightarrow\ 8.16E-4\frac{rem}{kW}\ \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.147\ rem$$

$$halogens\ (6\ hr\ decay) \Rightarrow\ 6.29E-4\frac{rem}{kW}\ \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.113\ rem$$

$$other\ fission\ products\ \Rightarrow\ 0.00\ rem$$

$$actinides \Rightarrow\ 0.00\ rem$$

$$Total \Rightarrow\ 0.260\ rem$$

A TEDE of 60 mrem for a stack release and 260 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- The maximum number of targets that can be processed in a dissolver box is 6 per day and 12 per week.
- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

13b.2.3.6 Facility Fire

1 – Uranium foil ignites during target disassembly (DB-FI-003)

During irradiated target disassembly in a dissolver box, a U foil ignites, releasing all its fission product and actinide inventory into the dissolver box. The ignition of a U foil is considered an unlikely event.

Scenario Development

To chemically extract the Mo-99 from an irradiated target, the target must be disassembled and the U foil removed from the Al target cladding, placed in the dissolver vessel, and dissolved in nitric acid. The U foil is removed from the cladding by using parting wheels to mechanically cut the outer cladding and separate the cladding from the foil. During this process no U powder, dust, shavings, or chippings are created. The target disassembly process is performed in a dissolver box.

Beta particles and gamma rays are emitted by the fission products in an irradiated target as they decay. The beta particles (electrons) have a relatively short range in the U and deposit their energy directly in the foil. Some of the gamma-ray energy is also deposited in the foil. It is estimated that the decay power from the beta particles and gamma-rays deposited in a U foil for a full-power target (30 kWt) irradiated for 25 days and decayed 4 hr. is approximately 102 watts.

The ignition of a U foil is unlikely for the following reasons:

- The irradiated U foil temperature, with 4 hr. of decay and in air, is below the spontaneous ignition point.
- The U foil is coated with nickel (Ni) metal that inhibits oxidation.
- There are no heat or ignition sources within the dissolver box.

Chapter 5b shows that the maximum temperature for a full-power irradiated target foil after a 4-hr. decay is less than 300°C (572°F). The temperature required for ignition of a U metal foil in air is 385°C (725°F) (Plys and Duncan, 2000). The U foil is also coated with a [[ ]]$^{PROP/ECI/SRI}$ thick Ni metal coating. A eutectic between the U and Ni can form at temperatures of about 740°C (1364°F). Below this temperature, the Ni coating inhibits oxidation of the U foil. The ignition temperature for Ni metal in oxygen gas is about 1450°C (2642°F) (Shao et al., 2020).

There are no other heat or ignition sources in the dissolver box that could ignite a U foil.

Consequence Analysis

For this accident it is assumed that an irradiated U foil ignites and releases all the fission products and actinides from one target that was irradiated at full power for 25 days and decayed for 4 hr. All the noble gases, halogens, other fission products, and actinides are assumed to be released into the dissolver box.

The noble gas, halogen, other fission product, and actinide inventory from one full power target (30 kWt each) decayed 4 hr. are released into the dissolver box. The downwind dose to a member of the public can be calculated using an LPF for the noble gases of 1.0; halogens, 0.001; other fission products, 0.0003; and actinides, 0.0003. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows:

Stack release at 600 m (1969 ft.):

$$noble\ gases\ (4\ hr\ decay) \Rightarrow\ 2.88E-4\frac{rem}{kW}\times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0086\ rem$$

$$halogens\ (4\ hr\ decay) \Rightarrow\ 1.39E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0042\ rem$$

$$other\ fp\ (4\ hr\ decay) \Rightarrow\ 1.62E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0049\ rem$$

$$actinides\ (4\ hr\ decay) \Rightarrow\ 1.79E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.00054\ rem$$

$$Total \Rightarrow\ 0.018\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases\ (4\ hr\ decay) \Rightarrow\ 1.17E-3\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0351\ rem$$

$$halogens\ (4\ hr\ decay) \Rightarrow\ 6.52E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0196\ rem$$

$$other\ fp\ (4\ hr\ decay) \Rightarrow\ 7.61E-4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0228\ rem$$

$$actinides\ (4\ hr\ decay) \Rightarrow\ 8.39E-5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 1\ target\ = 0.0025\ rem$$

$$Total \Rightarrow\ 0.080\ rem$$

A TEDE of 18 mrem for a stack release and 80 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

2 – Fire due to combustible materials or electrical short in UREX box (UP-FI-001)

During U purification activities in the UREX box, the TBP/dodecane solution ignites and releases fission products and actinides into the box. The ignition of the TBP/dodecane while performing U purification is considered an unlikely event.

Scenario Development

A mixture of TBP ($C_{12}H_{27}O_4P$) and dodecane ($C_{12}H_{26}$), a kerosene-like liquid, is used in the U recovery activities in the UREX boxes. The TBP/dodecane solution is reused repeatedly with each batch of U with fractional losses extracted with the fission product stream. Administrative

controls, including procedures and worker training, establish the limit on the TBP/dodecane solution used in the UREX box. The TBP/dodecane solution is flammable.

Consequence Analysis

For this accident it is assumed that the TBP/dodecane solution ignites in the UREX box while U purification activities are being performed. It is assumed that there are no noble gas or halogen fission products in the U solution because these were removed during the dissolution process in the dissolver box. During the fire, it is assumed that the actinides and other fission products are released into the UREX box. It is further assumed that the inventory from six irradiated targets irradiated at 30kWt for 25 days and decayed for 6 hr. is released.

The downwind dose to a member of the public can be calculated using an LPF for the other fission products, 0.0003; and for actinides, 0.0003. The MRF for all the radionuclides is assumed to be 1.0. The results are as follows.

Stack release at 600 m (1969 ft.):

$$noble\ gases \Rightarrow\ 0.000\ rem$$

$$halogens \Rightarrow\ 0.000\ rem$$

$$other\ fp\ (6\ hr\ decay) \Rightarrow\ 1.62 - 4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0292\ rem$$

$$actinides\ (6\ hr\ decay) \Rightarrow\ 1.79E - 5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0032\ rem$$

$$Total \Rightarrow\ 0.032\ rem$$

Ground release at 500 m (1640 ft.):

$$noble\ gases \Rightarrow\ 0.000\ rem$$

$$halogens \Rightarrow\ 0.000\ rem$$

$$other\ fp\ (6\ hr\ decay) \Rightarrow\ 7.61 - 4\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.137\ rem$$

$$actinides\ (6\ hr\ decay) \Rightarrow\ 8.39E - 5\frac{rem}{kW} \times 1.0\ \times 30\ kW\ \times 6\ targets\ = 0.0151\ rem$$

$$Total \Rightarrow\ 0.152\ rem$$

A TEDE of 32 mrem for a stack release and 152 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

For the worker, it is assumed that the activity occurs with no release from the UREX box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Technical Specification Considerations

- HCF ventilation system Zone 1a is a safety-related SSC and a designated ESF as described in Section 6b.1. HCF Zone 1a uses HEPA and charcoal filters with a decontamination factor of 1000 for the halogens. No filtering is assumed for the noble gases.
- The SCBs associated with the dissolution of irradiated targets (SCBs 2 – 7; four dissolver boxes and two R&D boxes) are safety-related SSCs. These SCBs establish a confinement boundary with the HCF ventilation system Zone 1a.

13b.2.3.7 Criticality Accidents

Potential criticality accidents in the different work areas of the HCF are investigated in this subsection of the accident analysis. A criticality accident in the HCF is considered a highly unlikely event. A preliminary criticality assessment for the HCF has been performed. For each work area where LEU could be processed or stored, the postulated criticality accidents shown in Table 13b.1-1 are investigated further.

1 – Target processing canyon and waste storage canyon

- DB-NC-001 – Nuclear criticality in dissolver box
- UP-NC-001 – Nuclear criticality in UREX process box
- WX-NC-001 – Nuclear criticality in cask loading bay

2 – SNM storage area

- SNMS-NC-001 – Nuclear criticality in SNM storage area

3 – Target fabrication area

- SNMB-NC-001 – Nuclear criticality in SNM blending area
- OMR-NC-001 – Nuclear criticality in oxide to metal reduction area
- IFP-NC-001 – Nuclear criticality in ingot to foil production area
- FTP-NC-001 – Nuclear criticality in foil to target production area

The greatest radiological consequences to the worker in the HCF are from exposure to unshielded radioactive materials and criticality events in unshielded areas. Lethal direct radiation exposures are possible for both types of accidents.

Criticality accidents are prevented by engineered and administrative controls placed on SNM mass and volume limitations throughout the HCF. For the SNM storage area and the target fabrication area, only U metals and oxides are in use during the process activities. Water is used in performing the U foil quenching process with limited numbers of foils. The Ni plating process of target foils in the target fabrication area is also performed in a liquid bath. Only flooding conditions could promote the possibility for a criticality accident in the SNM storage area. For the target processing canyon, targets are disassembled, and the U foil materials are dissolved in nitric acid in the dissolver boxes. The U is recovered and purified in a UREX process in batch operations in the UREX boxes. For the target processing canyon SCBs, the number of targets (SNM mass) in-process is controlled as well as the geometry of the containers.

The purpose of this accident analysis is to describe the conditions, assumptions, and use of SNM (LEU) in each of the HCF areas to show that a criticality event in the HCF is highly unlikely. This analysis is not intended to modify the requirements of the Nuclear Criticality Safety Program (NCSP). The EIPC maintains a NCSP as described in Chapter 6b. Included in the NCSP are the requirements to perform Criticality Safety Evaluations by certified Criticality Safety Engineers. Design, engineering, and administrative controls are developed in the Criticality Safety Evaluations to ensure that a criticality accident in the HCF is highly unlikely. As such, the intended purpose of this subsection and the EMIF preliminary criticality assessment is to provide information to show that criticality safety can be achieved throughout the HCF. A criticality accident alarm system (CAAS) is implemented for worker safety defense-in-depth as described in Chapter 6b.

American National Standards Institute/American Nuclear Society (ANSI/ANS) ANSI/ANS 8.1-2014, Nuclear Criticality Safety In Operations With Fissionable Material Outside Reactors (R2018) (ANSI/ANS, 2018), is used as guidance throughout this section. In particular, the uranium-235 (U-235) subcritical mass limits of 0.78 kilograms (kg) (1.72 lb.) in aqueous mixtures (Section 5.1 Aqueous Mixtures), 20.1 kg (44.3 lb.) for single-parameter subcritical limits for metal units (Section 5.3 Metallic Units), and 32.3 kg (71.2 lb.) for uranium dioxide (UO_2) single-parameter subcritical limits for oxides (Section 5.4 Oxides) are used extensively in this qualitative analysis, when applicable.

Scenario Development – Nuclear criticality in a dissolver box

Irradiated targets are transferred from the target receipt box to the dissolver box for processing. in the dissolver box, the targets are disassembled, and the U foils removed and placed in the dissolver unit. After the dissolver unit is loaded with U foils and sealed, nitric acid is used to dissolve the LEU into a uranyl nitrate ($UO_2(NO_3)_2$) solution. After complete dissolution, the solution is passed through a titania column to remove the Mo-99. The LEU in the uranyl nitrate solution with the fission products and actinides is then transferred to the UREX box for U separation and conversion to an oxide form. The process activities in the dissolver box are performed as a batch process.

The LEU physical forms that are in the dissolver box at any one time are targets, foils, and uranyl nitrate solution. The number of targets that can be dissolved in a dissolver box at any one time is six. The total number of irradiated targets that can be in-transfer to a dissolver box is 24.

From a criticality perspective, using the nominal target loading of [[ ]]$^{PROP/ECI/SRI}$ U-235 per target, over [[ ]]$^{PROP/ECI/SRI}$ dry targets are required to reach the single-parameter subcritical limit for metal units. For an aqueous mixture, 780 g (27.5 oz.) of U-235 is the subcritical mass limit, equivalent to [[ ]]$^{PROP/ECI/SRI}$ targets. Therefore, the six targets that can be processed in a dissolver box at one time represent a factor of [[ ]]$^{PROP/ECI/SRI}$ below the subcritical mass limit. Dissolution activities may be performed simultaneously in the other three dissolver boxes. These boxes are separated such that there is no neutronic interaction between the boxes.

Using the assumptions and constraints presented, the probability of a criticality event in a dissolver box is highly unlikely.

Scenario Development – Nuclear criticality in UREX process box

The LEU in the uranyl nitrate solution with the fission products and actinides is transferred to the UREX box for U separation and conversion to an oxide form. The process activities in the UREX box are performed as a batch process. The purified U is precipitated and heated and further chemically treated to form a solid oxide powder. The remaining solution (raffinate) has only a trace quantity of LEU and is transferred to the waste packaging box. The LEU oxide is then sampled and packaged for transfer to the SNM storage area of the HCF.

The LEU physical forms that are in the UREX box at any one time are uranyl nitrate solution or U oxide powder. The number of equivalent targets that can be staged or processed in a UREX box at one time is [[ ]]PROP/ECI/SRI, equivalent to [[ ]]PROP/ECI/SRI of U-235, which is below the 780 g (27.5 oz.) U-235 aqueous mixture subcritical mass limit. The subcritical mass limit is 32.3 kg (71.2 lb.) of U-235 in solid oxide form.

UREX activities may be performed simultaneously in the other UREX box. These boxes are separated such that there is no neutronic interaction between the boxes.

Using the assumptions and constraints presented, the probability of a criticality event in a UREX box is highly unlikely.

Scenario Development – Nuclear criticality in cask loading bay

Waste drums are loaded in the waste packaging box and staged in the waste storage canyon for decay for 6 months to 2 years. After decay, the waste drums are loaded into a Type B shipping container and transported to a Class C low-level waste disposal site.

The raffinate from the UREX process and other liquid waste from the modified Cintichem process are collected in the waste packaging box, combined in a waste drum with grout, and solidified. Up to 15 targets worth of waste can be packaged into one waste drum. The UREX process is expected to be at least 99 percent efficient in separating the U from the raffinate. At this value, less than 4 g (0.14 oz.) of U-235 is contained in each waste drum. If for some reason all the U was included in the raffinate, [[ ]]PROP/ECI/SRI of U-235 would be included in a waste drum for a 15-target loading. This value is below the 780 g (27.5 oz.) U-235 aqueous mixture subcritical mass limit.

Using the assumptions and constraints presented, the probability of a criticality event in the waste storage canyon or cask loading bay is highly unlikely.

Scenario Development – Nuclear criticality in SNM storage area

The SNM storage area stores unirradiated targets, U oxide powder, U metal ingots, and U metal foils in criticality safe configurations. At any one time there may be materials in any of these four forms in the SNM storage area. The forms are segregated and maintained in custom designed containers, drawers, and racks that are designed to be criticality safe in both dry and flooded conditions. Minimal moderator materials are used in the SNM storage area and designed into the containers, drawers, and racks. A total of [[ ]]SRI U-235, equivalent to [[ ]]SRI U at 19.75 percent enriched, can be stored at any given time.

Using the assumptions and constraints presented, the probability of a criticality event in the SNM storage area is highly unlikely.

Scenario Development – Nuclear criticality in SNM Blending area

The LEU available for use in the production of Mo-99 is depleted over time due to both U-235 burnup in the reactor core and from losses that occur in the fabrication activities. Some fresh 19.75 percent U-235 enriched material, in the form of an oxide, is added to the oxide stored from the U purification activities during UREX processing. This activity is performed in a hood or glovebox.

The LEU physical form that is in the target fabrication area glovebox for blending purposes is oxide powder. The mass of LEU in use for this activity is [[ ]]PROP/ECI/SRI LEU in the form of oxide powder, equivalent to [[ ]]PROP/ECI/SRI of U-235. The subcritical mass limit for U-235 in the form of oxide is 32.3 kg (71.2 lb.).

Using the assumptions and constraints presented, the probability of a criticality event in the target fabrication area from an SNM blending activity is highly unlikely.

Scenario Development – Nuclear criticality in oxide to metal reduction area

The U oxide that is recovered from the U purification activities during UREX processing is stored in individual containers in the SNM storage area in a criticality safe configuration until needed. Each container has about [[ ]]PROP/ECI/SRI of LEU in oxide form, equivalent to [[ ]]PROP/ECI/SRI of U-235. Containers are removed from the SNM storage area and the U oxide blended to form about [[ ]]PROP/ECI/SRI of LEU in oxide form. The oxide is mixed with a metal in the reduction vessel within a glovebox. During the reduction process, an LEU metal ingot is formed.

The LEU physical form that is in the target fabrication area glovebox for oxide to metal reduction is oxide powder converted to metal. The mass of LEU that is in use for this activity is [[ ]]PROP/ECI/SRI LEU in the form of oxide powder, equivalent to [[ ]]PROP/ECI/SRI of U-235. The subcritical mass limit for U-235 in the form of oxide is 32.3 kg (71.2 lb.). The subcritical mass limit for U-235 in metal form is 20.1 kg (44.3 lb.).

Using the assumptions and constraints presented, the probability of a criticality event in the target fabrication area from the oxide to metal reduction activity is highly unlikely.

Scenario Development – Nuclear criticality in ingot to foil production area

The LEU metal ingot formed in the oxide to metal reduction process is prepared for foil production by trimming it to size to form a [[ ]]PROP/ECI/SRI ingot. The remains are stored and used again in the next oxide to metal reduction activity. The prepared metal ingot is rolled into foils. Approximately [[ ]]PROP/ECI/SRI foils ([[ ]]PROP/ECI/SRI LEU metal) are produced from one ingot. The remains are stored and used again in the next oxide to metal reduction activity. The LEU physical form that is in the target fabrication area for foil production is a metal ingot and metal foils. The mass of LEU that is in use for this activity is [[ ]]PROP/ECI/SRI LEU metal in the form of a metal ingot converted to foils ([[ ]]PROP/ECI/SRI LEU, [[ ]]PROP/ECI/SRI U-235). The subcritical mass limit for U-235 in metal form is 20.1 kg (44.3 lb.).

Using the assumptions and constraints presented, the probability of a criticality event in the target fabrication area from the ingot to foil activity is highly unlikely.

Scenario Development – Nuclear criticality in foil to target production area

After the metal foils are produced, they are trimmed to size, weighed, and shaped into a cylindrical form. A Ni coating is plated on the foil using an electrolytic process. The number of cylindrical foils that can be placed in the Ni coating system is 20. The coated foils are then removed from the coating system, dried, and weighed. The foils are formed into targets using hydroforming equipment. The hydroforming system is designed to produce single or multiple targets at one time. The LEU physical form that is in the target fabrication area for Ni coating production and target fabrication is metal foils. The mass of LEU that is in use for this activity is 20 LEU metal foils ([[ ]]$^{PROP/ECI/SRI}$ U-235). For an aqueous mixture, 780 g (27.5 oz.) of U-235 is the subcritical mass limit. The subcritical mass limit for U-235 in metal form is 20.1 kg (44.3 lb.).

Using the assumptions and constraints presented, the probability of a criticality event in the target fabrication area from the foil to target activity is highly unlikely.

Technical Specification Considerations

- A NCSP is implemented for the EMIF (see Chapter 6b).
- Criticality Safety Evaluations are performed on all activities in the HCF requiring SNM usage, transfer, or storage.
- Material inventory limits are required in each area of the HCF.
- A CAAS is maintained in the HCF.

Table 13b.2-1
Leak Path Fractions

Chemical Group	LPF
Noble gases	1.0 – No filtering
Halogens	0.001 – Charcoal filters
Others	0.0003 – HEPA filters

Abbreviations: LPF = leak path fraction | HEPA = high efficiency particulate air

Table 13b.2-2
TEDE and Fraction of Total Downwind Dose for the Noble Gases, Halogens, Other Fission Products, and Actinides for Target Inventory per kWt Irradiated for 25 days

Chemical Group	Stack Release (600 m) 4-hr. decay TEDE (rem/kWt)	Stack Release (600 m) 6-hr. decay TEDE (rem/kWt)	Ground Release (500 m) 4-hr. decay TEDE (rem/kWt)	Ground Release (500 m) 6-hr. decay TEDE (rem/kWt)
Noble gases	2.88E-4 (0.47)	2.01E-4 (0.39)	1.17E-3 (0.44)	8.16E-4 (0.36)
Halogens	1.39E-4 (0.23)	1.34E-4 (0.26)	6.52E-4 (0.24)	6.29E-4 (0.27)
Other fission products	1.62E-4 (0.27)	1.62E-4 (0.31)	7.61E-4 (0.28)	7.61E-4 (0.33)
Actinides	1.79E-5 (0.03)	1.79E-5 (0.03)	8.39E-5 (0.03)	8.39E-5 (0.04)
Total	6.07E-4 (1.00)	5.15E-4 (1.00)	2.67E-3 (1.00)	2.29E-3 (1.00)

Abbreviations: TEDE = total effective dose equivalent | kWt = kilowatt thermal | m = meter(s) | hr. = hour(s)

Table 13b.2-3
Accidents Analyzed

Accident Category	Accident	PSAR Section
Criticality accidents	1. Target processing canyon and waste storage canyon 2. SNM storage area 3. Target fabrication area	13b.2.3.7
Maximum hypothetical accident	MHA – Fire due to combustible materials or electrical short in a dissolver box (DB-FI-001) – releases iodine and noble gases	13b.2.3.1
Loss of electrical power	Loss of electrical power during dissolver box activities (DB-EE-001)	13b.2.3.2
External events (meteorological, seismic, fire flood)	Seismic event breaches FGDS (FG-NP-001)	13b.2.3.3
Critical equipment malfunction	1. Dissolver unit ruptures during dissolver box activities (DB-RS-003) 2. Dissolver unit seal leaks during dissolver box activities (DB-RS-004) 3. FGDS ruptures (FG-RS-001)	13b.2.3.4
Operator error	Dissolver unit not evacuated following dissolution process (DB-RS-005)	13b.2.3.5
Facility fire	1. U foil ignites during target disassembly (DB-FI-003) 2. Fire due to combustible materials or electrical short in UREX box (UP-FI-001)	13b.2.3.6
Chemical release events	1. Chemical solution spill in packaging box or during transfer to the HCF high bay (PX-RS-001) 2. Nitric acid solution spill in dissolver box (DB-RS-001) 3. Chemical solution spill in purification box (PB-RS-001)	13b.3

Abbreviations: PSAR = Preliminary Safety Analysis Report | SNM = special nuclear material | FGDS = fission gas delay system | U = uranium | UREX = uranium extraction | HCF = Hot Cell Facility

13b.3 ANALYSIS OF ACCIDENTS WITH HAZARDOUS CHEMICALS

Chemical solutions are used in the HCF for the following activities:

- Dissolution of irradiated target U foils – dissolver boxes.
- Purification of the Mo-99 product – purification boxes.
- Purification of the LEU and oxide conversion – UREX boxes.
- U foil electrolytic Ni coating – target fabrication area.

All these activities are performed in the SCBs of the target processing canyon with the exception of the Ni coating process, which is performed in the target fabrication area.

The main chemical solutions that are used in the dissolver boxes, purification boxes, and UREX boxes include:

- Nitric acid (HNO_3)
- Sodium hydroxide (NaOH)
- Sulfuric acid (H_2SO_4)
- TBP ($C_{12}H_{27}O_4P$)
- Dodecane ($C_{12}H_{26}$)

The estimated quantities of chemical solutions that are used in a dissolver box, purification box, UREX box and target fabrication area are as follows:

Dissolver box:

- Dissolution of irradiated target U foils – 6 targets – [[ ]]$^{PROP/ECI/SRI}$ U metal:
  - Nitric acid (HNO_3) – 1.1 L (0.29 gal.) azeotrope (15.8 molar [M]) = 1.1 kg (2.4 lb.) HNO_3.

Purification box:

- Mo-99 purification:
  - Sodium hydroxide (NaOH) – 3 L (0.8 gal.) 0.1 M = 0.012 kg (0.026 lb.) NaOH.
  - Sulfuric acid (H_2SO_4) – 0.15 L (0.04 gal.) 2 M = 0.029 kg (0.064 lb.) H_2SO_4.

UREX box:

- U purification – 6 targets – [[ ]]$^{PROP/ECI/SRI}$ U:
  - Nitric acid (HNO_3) – 4.6 L (1.2 gal.) azeotrope (15.8 M) = 4.6 kg (10.1 lb.) HNO_3.
  - Sodium hydroxide (NaOH) – 0.13 L (0.03 gal.) 4 M = 0.02 kg (0.04 lb.) NaOH.
  - TBP ($C_{12}H_{27}O_4P$) – [[ ]]$^{PROP/ECI}$.
  - Dodecane ($C_{12}H_{26}$) – [[ ]]$^{PROP/ECI}$.

Target fabrication area:

- U foil Ni coating in electrolytic solution:
  - Electrolytic solution – 5 L (1.3 gal.).

For the Mo-99 purification process in the purification box, small quantities (tens of milliliters) of carrier solutions are used to process six targets of Mo-99 inventory. These carrier solutions include the following:

- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI
- [[ ]]PROP/ECI

No chemical preparation or bulk chemical storage is performed in the HCF. Bulk chemical storage and the preparation of the dissolution, carrier, and purification solutions are performed in the production warehouse and the production office complex (POC) outside of the EMIF.

Kits are prepared in the POC for each batch of targets for the activities associated with each SCB. The kits associated with the day's activities are delivered to the HCF prior to the commencement of the processing activities. The kits are identified as unique to each activity and include all the chemical solutions, hardware, and other materials required to perform the activity in the SCB. The exception is the TBP/dodecane, which remains in the UREX box and is reused.

The chemicals are totally consumed during the activities within the SCBs. The exception is the TBP/dodecane, which remains in the UREX box and is reused. No chemicals are removed from the canyon area. All chemical solutions are neutralized and solidified as a grout prior to exiting the waste packaging box in a waste drum.

The total quantities of chemicals consumed in a year when processing 30 targets per week are as follows:

- Nitric acid – 1450 kg (3197 lb.) HNO_3 = 1450 L (383 gal.) azeotrope (15.8 M) HNO_3.
- Sodium hydroxide – 50 kg (110 lb.) NaOH pellets.
- Sulfuric acid – 10 kg (22 lb.) H_2SO_4 = 5.5 L (1.5 gal.) azeotrope (18.4 M) H_2SO_4.
- TBP – [[ ]]PROP/ECI.

- Dodecane – [[ ]][PROP/ECI].

The quantity of chemical solution available in an accident during staging or transfer in the HCF for use is small. Less than 5 L (1.3 gal.) of equivalent azeotrope nitric acid is in a kit for target foil dissolution and processing.

Chemical solution spill in packaging box or during transfer to the HCF high bay (PX-RS-001)

Nitric acid solution spill in dissolver box (DB-RS-001)

Chemical solution spill in purification box (PB-RS-001)

Scenario Development

Relatively small volumes of chemical solutions are used in the dissolution, processing, and purification activities to produce Mo-99 from targets. For six target U foils at [[ ]][PROP/ECI/SRI] of U each, about 12 g-mols (0.026 lb-mols) of nitric acid are required to dissolve the foils in a dissolver unit. This is equivalent to 0.75 L (0.20 gal.) of azeotrope (15.8 M) nitric acid. Relatively small volumes of nitric acid are also used in the purification box, and the UREX box to recover the U from the solution.

During the transfer of a kit to the HCF from the POC, staging of a kit in the HCF, transfer of a kit into a packaging box, or when the kit contents are located within an SCB, the kit container leaks, breaks, or is otherwise compromised, spilling its contents on the floor of the HCF or in an SCB. This scenario is considered a not unlikely event.

Because the volumes of the chemical solutions used in processing kits are small, cleanup of a spill is by using spill kits and neutralizing absorbers throughout the facility. The HCF staff are trained in the proper response to a chemical spill. A spill in an SCB is treated in a similar fashion. A spill kit or neutralizing absorber is contained for disposal through the waste processing box.

Consequence Analysis

A nitric acid spill was analyzed assuming the spill occurred on the floor of the HCF with workers present or in an SCB. The assumption is that the acid pool evaporates after the spill and is cleaned up by the HCF staff some unspecified time later. The methodology for determining the spill area release rate from evaporation is presented in NUREG/CR-6410, Nuclear Fuel Cycle Accident Analysis Handbook, formulas B.3-B.5. The following assumptions and liquid properties were used in the calculation:

Spill diameter = 10 m

Wind speed = 1.5 m/s

Temperature = 20°C

Kinematic viscosity of air = 1.51E-5 square meters (m^2)/s

Molecular diffusivity of vapor in air = 1.18E-5 m^2/s

Nitric acid molecular weight = 63.01 atomic mass units

Nitric acid vapor pressure = 9.87E3 pascal

The evaporation release rate is calculated to be 45.2 milligrams (mg) (HNO_3)/s. Note that this calculation is independent of the total volume spilled. A spill of 5 L (1.3 gal.) of acid would take tens of hours to evaporate if it were not cleaned up by the HCF staff.

If the spill occurs on the HCF floor, the evaporating nitric acid vapor fills the HCF Zone 3 volume (inhabited worker space) and is released to the environment through the HCF exhaust stack. If the spill occurred in a dissolver box, the evaporating nitric acid vapor fills the SCB and is released to the environment through the HCF Zone 1a exhaust stack.

The chemical exposure to a member of the public from a nitric acid spill that is not immediately cleaned up can be calculated as follows. Using the calculated evaporation rate of the spill and a χ/Q value of 4.07E-4 (s/m^3) (same value used in the radionuclide release calculations from the 15 m high stack), the concentration of the nitric acid at 600 m (1969 ft.) from the HCF stack is 0.018 mg/m^3 or 0.0071 parts per million (ppm). The Protective Action Criteria (PAC) from Tables Rev. 29a of the United States Department of Energy Chemicals of Concern and Associated Chemical Information (DOE, 2018) for nitric acid are 0.16 ppm, 24 ppm, and 92 ppm for PAC-1, PAC-2, and PAC-3. The calculated value from the release from the HCF exhaust stack is less than the PAC-1 value.

The chemical exposure to a worker in the HCF from a nitric acid spill that is not immediately cleaned up can be calculated as follows. Using the calculated evaporation rate from the spill, the room exhaust exchange rate (six room exchanges per hour), and the room volume (1.13E4 m^3 [399,000 cubic feet]) the equilibrium concentration of nitric acid in the HCF Zone 3 is calculated to be 2.40 mg/m^3 or 0.93 ppm. The Occupational Safety and Health Administration airborne permissible exposure limit (PEL) for a worker is 2 ppm over an 8-hr. work shift. The calculated room concentration is less than the PEL value.

Technical Specification Considerations

None.

13b.4 SUMMARY AND CONCLUSIONS

Chapter 13b presented seven postulated event categories for accident scenarios for the HCF. A preliminary ISA (Appendix 13b.A) was used to identify potential events that could lead to the release of radionuclides or radiation exposure to the public, the worker, and the environment. Controls were identified in the preliminary ISA that would prevent the accident or mitigate the consequences of the accident. Events were selected within each category for further evaluation. The summary of the accident dose consequences is presented in Table 13b.4-1.

The MHA, a release of iodine from iodine traps and noble gases from the FGDS, bounds all the accident dose consequences. A TEDE of 117 mrem for a stack release and 524 mrem for a ground release are calculated for a member of the public. These values are below the accident dose criterion of 1.0 rem.

At 2500 m (1.6 mi.) (i.e., closer than the nearest resident), assuming that the wind is blowing in a west-northwest direction from the HCF, a TEDE of 62 mrem for a stack release and 78 mrem for a ground release are calculated. The prevailing wind direction at the EIPC site is from the south.

For the worker, it is assumed that the activity occurs with no release from the dissolver box (HCF Zone 1a) into the worker area (HCF Zone 3) of the HCF. There is no worker dose for this accident.

Table 13b.4-1
Summary of Accident Dose Consequences

Accident Scenario	15 m Stack Release at 600 m TEDE (mrem)	Ground Release at 500 m TEDE (mrem)
MHA – Iodine trap release	117	524
Loss of electrical power	N/A	N/A
External events – FGDS breach from seismic event	40	161
Critical equipment malfunction		
1. Dissolver unit rupture	93	412
2. Dissolver seal leaks	60	260
3. FGDS rupture	60	260
Operator error – Dissolver unit not evacuated	60	260
Facility fire		
1. U foil ignites	18	80
2. TBP/dodecane	32	152
Criticality accidents	N/A	N/A

Abbreviations: m = meter(s) | TEDE = total effective dose equivalent | mrem = millirem | MHA = maximum hypothetical accident | N/A = not applicable | FGDS = fission gas delay system | U = uranium | TBP = tributyl phosphate

13b.5 REFERENCES

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APPENDIX 13b.A

SUMMARY DESCRIPTION OF THE PRELIMINARY INTEGRATED SAFETY ANALYSIS

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APPENDIX 13b.A
SUMMARY DESCRIPTION OF THE PRELIMINARY INTEGRATED SAFETY ANALYSIS

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Appendix 13b.A Summary Description of the Preliminary Integrated Safety Analysis

13b.A.1 PURPOSE

This document presents the methodology for the preliminary Integrated Safety Analysis (ISA) for the Hot Cell Facility (HCF), which is part of the Eden Medical Isotope Facility (EMIF). Preliminary results are described in this Appendix as well as in various sections of Chapter 13b. This document provides a comprehensive preliminary identification and evaluation of the hazards and controls for HCF operations that include target transfer, target processing, product purification and shipping, uranium recovery, waste packaging, storage, and shipping, uranium storage, and target fabrication.

The fabrication of targets at the HCF target fabrication area will be under a Title 10 of the Code of Federal Regulations (10 CFR) Part 70 special nuclear material license that is separate from the 10 CFR Part 50 utilization and production facility licenses that are the subject of this application. The 10 CFR Part 70 license will be the subject of a future application to the United States Nuclear Regulatory Commission (NRC). The target fabrication process is discussed in this preliminary ISA to allow a complete discussion of potential activities within the EMIF.

13b.A.2 DOCUMENTS USED AS GUIDANCE TO DEVELOP THE INTEGRATED SAFETY ANALYSIS

The regulations in 10 CFR 70.60 state, in part, that "… the regulations in § 70.61 through § 70.76 do not apply to activities that are certified by the Commission pursuant to part 76 of this chapter or licensed by the Commission pursuant to other parts of this chapter." The HCF is licensed pursuant to 10 CFR Part 50. While not a requirement, a preliminary ISA has been developed by Eden following the guidance of the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Parts 1 and 2, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content, for Licensing Radioisotope Production Facilities and Aqueous Homogenous Reactors.

This section identifies the guidance documents that are recommended to develop a preliminary ISA for the HCF portion of the EMIF.

- NUREG-1513, Integrated Safety Analysis Guidance Document
- NUREG-1520, Standard Review Plan for Fuel Cycle Facilities License Applications, Revision 2
- NUREG-1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content (Part 1 and 2)
- ISG Augmenting NUREG-1537
- Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples, developed by the American Institute of Chemical Engineers (AIChE, 1992)

13b.A.3 INTEGRATED SAFETY ANALYSIS

As defined by the NRC in NUREG-1513, "An Integrated Safety Analysis is a systematic examination of a facility's processes, equipment, structures, and personnel activities to ensure that all relevant hazards that could result in unacceptable consequences to potential receptors have been adequately evaluated and appropriate protective measures have been identified."

The approach used for the ISA consisted of two phases. The first phase used the “what if/checklist” methodology to qualitatively evaluate the broad range of hazards and potential accidents and to identify credible accidents of potential concern. Once credible accidents of concern were identified, other quantitative methodologies were employed to analyze in detail the most significant of those accidents to determine the maximum hypothetical accident (MHA) and what accidents are bounded by the MHA.

The steps for conducting Phase I of the preliminary ISA consisted of the following:

1. Identify the activities for the HCF.
2. Identify the hazards associated with these activities using process knowledge and a checklist.
3. Analyze the hazards using a “what-if” methodology to identify the frequency, consequences, and risk associated with potential accidents.
4. Identify possible controls (preventative and mitigative).
5. Identify accidents of concern for further accident analysis.
6. Perform detailed analysis on selected accidents (Phase II – Chapter 13b of the Preliminary Safety Analysis Report [PSAR]).

13b.A.3.1 IDENTIFY THE ACTIVITIES – STEP 1

The first step of the preliminary ISA consisted of defining and categorizing the HCF operations by general activity. The activities are grouped by tasks and operations performed in each steel confinement box (SCB) and other areas in the HCF. Interfaces between the facilities and activities were identified to assist in determining external events that may contribute to the initiation of radiological incidents within the facility.

The following list of activity groups was identified as these groups relate to the types of work activities in the HCF. Activity groups 1 through 8 are performed within SCBs in the target processing canyon. Activity groups 9 and 10 are performed in the waste storage canyon and waste shipping area. Activity group 11 is performed in the shipping area. Activity group 12 is performed in the special nuclear material (SNM) storage area. Activity groups 13 through 16 are performed in the target fabrication area.

13b.A.3.1.1 Target Processing Canyon

Activity Group No. 1 – Target Receipt (TR) Box

Activity Group No. 2 – Dissolver Box (DB)

Activity Group No. 3 – Purification Box (PB)

Activity Group No. 4 – Fission Gas (FG) Delay System

Activity Group No. 5 – Process Gas System (PG)

Activity Group No. 6– Packaging Box (PX)

Activity Group No. 7 – Uranium Extraction (UREX) Process Box (UP)

Activity Group No. 8 – Waste Packaging (WP) Box

13b.A.3.1.2 Waste Storage Canyon

Activity Group No. 9 – Waste Storage (WS) Canyon

13b.A.3.1.3 Cask Loading Bay

Activity Group No. 10 – Waste Shipping (WX)

13b.A.3.1.4 Product Shipping Area

Activity Group No. 11 – Product Shipping (PS)

13b.A.3.1.5 SNM Storage Area

Activity Group No. 12 – SNM Storage (SNMS)

13b.A.3.1.6 Target Fabrication Area

Activity Group No. 13 – SNM Blending (SNMB)

Activity Group No. 14 – Oxide to Metal Reduction (OMR)

Activity Group No. 15 – Ingot to Foil Production (IFP)

Activity Group No. 16 – Foil to Target Production (FTP)

13b.A.3.2 IDENTIFY HAZARDS – STEP 2

Each of the activities identified in Step 1 was evaluated to assess the potential exposure to radiological and chemical hazards. Hazardous materials and energy sources associated with EMIF operations and inventory were identified and characterized. Several sources of information, including input from appropriate subject matter experts, preliminary design information, and safety analysis of similar facilities, were reviewed to identify the hazardous material inventory, potential energy sources, and potential credible accident events. A checklist was used to categorize hazards based on type (e.g., kinetic, radiological, flammability), and assisted evaluators in producing a comprehensive list. Identified hazards were correlated with associated activities and locations in the facility. Quantities present in the facility were also noted as bounding maximum values. The result of this step was a compilation of the Material at Risk (MAR).

The release of hazardous chemicals is also included within the scope of this preliminary ISA but only to the extent that such hazardous releases result from the processing of licensed nuclear material or have the potential to adversely affect radiological safety.

Standard industrial hazards (SIH) are hazards that are routinely encountered in general industry and construction. These workplace hazards are addressed by provisions of 10 CFR Part 851, Worker Safety and Health Program, which requires identification and assessment of worker hazards and compliance with safety and health standards that provide specific safe practices and controls. SIH were not included in the scope of the preliminary ISA.

During the evaluation process, hazards were screened and considered to be an SIH if they met any of the following criteria:

- Commonly accepted industrial hazards (e.g., burns, shocks, and confined spaces).
- Insignificant quantities of hazards.
- Low hazards addressed by an existing Management Measure (e.g., Industrial Hygiene Program).
- If the hazard occurs in conjunction with a radiological release, the non-radiological hazards were deemed insignificant in comparison to the radiological hazard.
- Used by and available to the general public in the same quantity, form, and concentration (e.g., cleaning solutions, lubricants, motor oils).
- Materials with National Fire Protection Association ratings for health, flammability, and reactivity of “0” or “1.”

The radioactive and chemical material inventories for the HCF used for the hazard analysis are presented in Table 13b.A-1 for the target processing canyon and waste storage canyon and Table 13b.A-2 for the target fabrication area. Additional chemicals and volumes used in the modified Cintichem process are presented in Table 13b.A-3.

The most significant radionuclide inventory associated with the HCF is that generated in the reactor as fission products, activation products, and actinides. Most of these radionuclides are fission products produced by irradiation of low-enriched uranium (LEU) within the targets.

Throughout operations within the HCF, the primary hazard concern is the more mobile radioactive species such as noble gases and halogens. All other radionuclides are either retained in their host medium or are easily captured and controlled by filtration. Engineered provisions to minimize the release of noble gases and halogens minimize the release of other nuclides as well.

The identified significant radionuclide inventory associated with the target fabrication area of the HCF is LEU in the form of oxide powder and metal. There are a few trace fission products remaining in the LEU recovered from the UREX process, but these are expected to be minimal. The goal of the UREX process is to remove as much as 99.99 percent of the fission products from the LEU. The hazard to the worker is an inadvertent nuclear criticality event or a drop or impact to a container with LEU oxide powder. There are no public concerns associated with the target fabrication area of the HCF.

Table 13b.A-1
(Sheet 1 of 2)
Hot Cell Facility Target Processing Canyon and Waste Storage Canyon Radiological and Chemical Hazards

Item	MAR and/or Exposure	Basis/Importance
Irradiated target direct radiation exposure rate	27,000 R/hr at 1 m	Represents a potential lethal dose to directly exposed workers from a single irradiated target
Waste from targets grouted in 55-gallon drums and stored in the Waste Storage Canyon	30 R/hr at 1 m per drum for 15 targets of fission product inventory and 1-year decay 121 Ci fission products per target decayed for 1 year	Radiation exposure rate as a function of storage time from fission products decreases but remains a significant hazard to the exposed workers
Target	[[ ]]$^{PROP/ECI/SRI}$ g LEU [[ ]]$^{PROP/ECI/SRI}$ g U-235	Amount of U-235 is [[ ]]$^{PROP/ECI/SRI}$ g per target in the reference design
Fission products per target operated at 30 kWt for 25 days and 4-hr decay	Total = 31,000 Ci Noble gases = 3000 Ci Halogens = 4500 Ci	Noble gases and halogens could be released within the dissolver box during target processing
Iodine trap for processing of six targets	27,000 Ci	Iodine trap maintains copper shavings that form CuI
Target processing canyon fission product inventory during processing (all SCBs)	24 targets Total = 744,000 Ci Nobles = 72,000 Ci Halogens = 108,000 Ci	Total MAR for maximum target processing capability
Mo-99 per target at 4-hr decay	1440 Ci	Mo-99 production for a 30-kWt target operated for 25 days
Mo-99 product per target at 4-hr decay	720 R/hr at 1 m	unshielded
I-131 product per target at 10-day decay	270 Ci and exposure rate of 190 R/hr at 1 m	unshielded

Table 13b.A-1
(Sheet 2 of 2)
Hot Cell Facility Target Processing Canyon and Waste Storage Canyon Radiological and Chemical Hazards

Item	MAR and/or Exposure	Basis/Importance
Xe-133 product per target at 10-day decay	510 Ci and exposure rate of 40 R/hr at 1 m	unshielded
Uranium oxide	[[ ]]$^{PROP/ECI/SRI}$ kg LEU	UREX process
Nitric acid (HNO_3) Azeotrope (15.8 M)	1 L dissolution 0.1 L column wash Dissolver box 4.6 L UREX box	Required for processing six targets of [[ ]]$^{PROP/ECI/SRI}$ g LEU per target
Sodium hydroxide (NaOH)	3 L 0.1N column wash purification box 0.13 L 4N UREX Box	Required for modified Cintichem process for six targets
Tributyl phosphate (TBP)	[[ ]]$^{PROP/ECI}$ L UREX Box	Reused in the UREX process
Dodecane	[[ ]]$^{PROP/ECI}$ L UREX Box	Reused in the UREX process
Shielded radiation exposure rate – occupied area	0.5 mR/hr at 1 m from target processing canyon wall	Design criteria for target processing canyon and waste storage canyon
Radiation exposure rate – not routinely accessible areas	30 R/hr at 1m	Design criteria for non-accessible areas
Nuclear criticality	10^{17} fissions	Represents a potential lethal dose to directly exposed workers

Abbreviations: MAR = Material at Risk | R/hr = roentgen per hour | m = meter(s) | Ci = curie(s) | g = gram(s) | LEU = low-enriched uranium | U-235 = uranium-235 | kWt = kilowatt thermal | hr. = hour(s) | CuI = copper iodide | SCB = steel confinement box | Mo-99 = molybdenum-99 | I-131 = iodine-131 | Xe-133 = xenon-133 | kg = kilogram(s) | M = molar | L = liter(s) | UREX = uranium extraction | N = normality

Table 13b.A-2
Hot Cell Facility Target Fabrication Area Material at Risk

Item	MAR	Basis/Importance
LEU SNM storage	[[ ]]^{SRI} kg LEU	Estimated quantity in storage
Uranium oxide HCF SNM storage	[[ ]]^{SRI} kg LEU	Estimated quantity in storage
Uranium oxide to metal conversion	[[ ]]$^{PROP/ECI/SRI}$ kg LEU	
Uranium ingots	[[ ]]$^{PROP/ECI/SRI}$ kg LEU	[[ ]]^{SRI} kg estimated quantity in storage
Uranium foils	[[ ]]$^{PROP/ECI/SRI}$ g LEU	[[ ]]^{SRI} foils estimated quantity in storage
Uranium targets	[[ ]]$^{PROP/ECI/SRI}$ g LEU	[[ ]]^{SRI} targets estimated quantity in storage
Nuclear criticality	10^{17} fissions	

Abbreviations: MAR = Material at Risk | LEU = low-enriched uranium | SNM = special nuclear material | kg = kilogram(s) | HCF = Hot Cell Facility | g = gram(s)

Table 13b.A-3
Other Chemical Hazards Used in the Modified Cintichem Process

Item	Constituents	Quantity Used Per Target (mL)
[[	[[	[[
]]PROP/ECI	]]PROP/ECI	]]PROP/ECI

Abbreviations: mL = milliliter(s) | mg = milligram(s) | [[

]]PROP/ECI

13b.A.3.3 ANALYZE HAZARDS – STEP 3

The analytical method used to evaluate the hazards was the “what if/checklist” hazard analysis. This method is an accident-scenario-based form of analysis. Potentially hazardous situations were first postulated as event scenarios. These scenarios were then evaluated with respect to causes, preventive features, initiating frequency, mitigative features, unmitigated consequence, risk, and other considerations. Estimates of the qualitative consequence severities and the initiating frequencies were generated and then used to categorize the hazards into bins for frequency, consequence, and risk for the three receptors: worker, public, and the environment.

The development of credible event scenarios involved assessing each HCF activity in detail and identifying initiating events and event scenarios that could result in the release of – or exposure to – the hazards and MAR identified in Subsection 13b.A.3.2. The quantity, form, and type of hazards (MAR and/or exposure rate) associated with each event were identified and protective features for the activity or the facility were noted. The listed protective features became candidates for safety-related systems, structures, and components (SSCs) or administrative controls given in the technical specifications (TSs) or TS required procedures.

Events were categorized by event type, which involved a subjective binning of events for comparative purposes. Event types include the following:

- Radiation exposure (RE)
- Fire (FI) including chemical
- Releases/spills (RS) including gases or liquids
- Nuclear criticality (NC)
- Natural phenomena (NP)
- External events (EE)

Events were also categorized based on work activity (e.g., target receipt, dissolution, purification, and packaging).

A qualitative assessment of each event and associated hazard was performed with respect to causes, preventive features, initiating frequency, mitigative features, unmitigated consequence, risk, and other considerations. The probability of occurrence, consequences, and risk categories that were assigned were consistent with the definitions in NUREG-1520.

The unmitigated “initiating frequency” or probability of occurrence was assigned according to Categories I, II, and III, as defined in Table 13b.A-4. Each receptor (the worker, public, and environment) affected by the event was then assigned an unmitigated consequence severity category (“A,” “B,” or “C”), as set forth in Table 13b.A-5.

The unmitigated consequence is a qualitative estimate of the worker, public, or environment impact resulting from the incident, unmitigated by any active system such as filters in a ventilation system. Passive engineered features, such as shielding and the distance to the site boundary, were factored into the qualitative consequence assessment. These passive engineering features were identified as Initial Conditions and are considered potential candidates for safety-related SSCs. For facility workers, the “A” category event is typified by a prompt worker fatality. A “B” category event results in a significant radiological dose (greater

than [>] 25 rem). The unmitigated risk bin, a qualitative ranking of the combination of the initiating frequency and the unmitigated consequence, was then assigned to the receptor affected, according to Table 13b.A-6 risk-ranking matrix. Note that the only acceptable risk ranking are for those event scenarios with a consequence category of “C” because of the dose criterion limit of 1 rem total effective dose equivalent (TEDE) for a member of the public as established in 10 CFR 50.34(a)(1)(i). This risk-ranking matrix differs from that in NUREG-1520, Table A.3.

Hazard Evaluation Tables for unmitigated event scenarios for the HCF were developed. The development of the unmitigated event scenarios involved assessing the HCF activities associated with the event type, identifying initiating events and event scenarios that could result in the release of, or exposure to, the hazards and MAR identified in the Hazard Identification (Step 2, Subsection 13b.A.3-2). The quantity, form, and type of hazards (MAR and/or exposure rate) associated with each event were identified and protective features for the activity or the facility were noted. The listed protective features became candidates for safety-related SSCs. Events were categorized by event type, which involved a subjective binning of events for comparative purposes. Event types include radiation exposure, fire (including chemical), releases/spills (gas or liquids), nuclear criticality, natural phenomena, and external events. Events were also categorized based on activity category.

The analysis of events categorized by event type and activity category will be provided in the final ISA to be submitted as a part of the Operating License Application.

Table 13b.A-4
Frequency Categories

Category	Category Descriptor	Frequency (F) Per Year
I	Not Unlikely	F greater than (>) 10^{-4}
II	Unlikely	F less than or equal to (≤) 10^{-4} and greater than (>) 10^{-5}
III	Highly unlikely	F less than or equal to (≤) 10^{-5}

Table 13b.A-5
Consequence Severity Category

Category	Affected Receptor		
	Facility Worker	**Public**	**Environment**
A	Loss of life, serious injury, or immediate life-threatening radiological doses Greater than or equal to (≥) 100 rem acute **OR** Chemical release that endangers life	Greater than or equal to (≥) 25 rem **OR** Greater than or equal to (≥) Protective Action Criteria 3 (PAC-3)	N/A
B	Significant radiological dose, significant injury or disability Greater than (>) 25 rem acute to less than (<) 100 rem acute **OR** A chemical exposure with long lasting health effects	Greater than or equal to (≥) 1 rem[(a)] **OR** Greater than or equal to (≥) PAC-2	Radioactive releases greater than (>) 5000 times Table 2 of 10 CFR Part 20, Appendix B
C	Radiological and chemical exposures less than (<) those above.	Radiological and chemical exposures less than (<) those above	Releases less than (<) those above

a) Dose criterion limit for a member of the public from 10 CFR 50.34(a)(1)(i) is 1 rem TEDE.
Abbreviations: N/A = not applicable | CFR = Code of Federal Regulations | TEDE = total effective dose equivalent

Table 13b.A-6
Risk-Ranking Matrix

Consequence Severity Category[a]	Frequency Category		
	III	**II**	**I**
A	Unacceptable Risk	Unacceptable Risk	Unacceptable Risk
B	Unacceptable Risk	Unacceptable Risk	Unacceptable Risk
C	Acceptable Risk	Acceptable Risk	Acceptable Risk

a) Risk rankings differ from those in NUREG-1520, Table A.3 because of the dose criterion limit for a member of the public from 10 CFR 50.34(a)(1)(i) of 1 rem TEDE, and the facility worker dose criterion of a 5 rem limit from 10 CFR 20.1201.
Abbreviations: CFR = Code of Federal Regulations | TEDE = total effective dose equivalent

13b.A.3.4 SAFETY CLASSIFICATION SELECTION – STEP 4

Hazard Evaluation Tables were developed and selected controls were identified that became candidates for safety-related SSCs, TS, and administrative controls. These controls either prevent or mitigate the hazard to the worker, public, or the environment.

The control selection strategy translated into the following hierarchy of controls, listed from the most preferred to least preferred:

1. Engineered controls that are preventive and passive.
2. Engineered controls that are preventive and active.
3. Engineered controls that are mitigative and passive.
4. Engineered controls that are mitigative and active.
5. Administrative controls that are preventive.
6. Administrative controls that are mitigative.

Engineered controls that are needed to reduce the dose to a member of the public to acceptable levels are considered engineered safety features. The final ISA will be submitted as a part of the Operating License Application.

13b.A.3.5 IDENTIFY ACCIDENTS FOR ANALYSIS – STEP 5

The first step of the preliminary ISA consisted of defining and categorizing the HCF activities. Those events with greater potential unmitigated consequences, a higher frequency of occurrence, unusual event dynamics, protective features unique to the event, or that were included in guidance from NUREG-1537 were selected for further evaluation in the control selection tables. All unmitigated events with an “Unacceptable” risk ranking for the worker, public, or the environment were selected, along with other unique events, for further quantitative evaluation. Refer to PSAR Subsection 13b.2.3. The guidance in NUREG-1537 suggests that a detailed accident analysis of categories of accidents be developed, as listed in Table 13b.A-7. The table shows the corresponding ISA events that were selected for that category. Events that are specific to worker exposure to high direct radiation environments are not included in the table. In some cases, multiple events (nuclear criticality, critical equipment malfunctions, and fires) were evaluated to ensure comprehensive evaluation of these unmitigated high-risk events.

13b.A.3.6 PERFORM DETAILED ANALYSIS ON SELECTED ACCIDENTS (CHAPTER 13B)

Refer to PSAR Subsection 13b.2.3 for the analysis of the selected accidents in Table 13b.A-7.

Table 13b.A-7
(Sheet 1 of 2)
Accident Initiating Events Requiring Further Analysis

Accident Category	ISA Event
Nuclear criticality accidents	**Target Processing Canyon and Waste Storage Canyon** DB-NC-001 – Nuclear criticality in dissolver box UP-NC-001 – Nuclear criticality in UREX process box WX-NC-001 – Nuclear criticality in cask loading bay **SNM Storage Area** SNMS-NC-001 – Nuclear criticality in SNM storage area **Target Fabrication Area** SNMB-NC-001 – Nuclear criticality in SNM blending area OMR-NC-001 – Nuclear criticality in oxide to metal reduction area IFP-NC-001 – Nuclear criticality in ingot to foil production area FTP-NC-001 – Nuclear criticality in foil to target production area
Loss of off-site electrical power	DB-EE-001 – Loss of off-site electrical power during dissolver box activities
External events – meteorological, seismic, fire, flood, wind	TR-NP-001 – Seismic Event – Target receipt box fails DB-NP-001 – Seismic Event – Dissolver unit and box fails FG-NP-001 – Seismic Event – Fission gas delay system fails UP-NP-001 – Seismic Event – UREX process box fails WP-NP-001 – Seismic Event – Waste packaging box fails WS-NP-001 – Seismic Event – Waste drum transfer system fails
Critical equipment malfunction	DB-RS-003 – Dissolver unit ruptures during dissolver box activities DB-RS-004 – Dissolver unit seal leaks during dissolver box activities DB-RS-006 – Fission product solution leaks during transfer activities FG-RS-001 – Fission gas delay system ruptures FG-RS-002 – Fission gas delay system leak UP-RS-002 – UREX system ruptures during process box activities UP-RS-003 – UREX system seal leaks during process box activities UP-RS-004 – Raffinate solution leaks during transfer activities

Table 13b.A-7
(Sheet 2 of 2)
Accident Initiating Events Requiring Further Analysis

Accident Category	ISA Event
Critical equipment malfunction (continued)	WP-RS-002 – Waste drum ruptures or leaks during waste packaging box activities
	WP-RS-003 – Raffinate solution leaks or spills during waste packaging operations
Operator error	DB-RS-005 – Dissolver unit not evacuated following dissolution process
	FG-RS-003 – Fission gas delay system inadvertently purged
	WS-RS-001 – Waste drum ruptures or leaks during transfer due to dropping
Facility fire	DB-FI-001 – Fire due to combustible materials or electrical short in dissolver box
	DB-FI-002 – Fire spreads to dissolver box
	DB-FI-004 – Uranium foil ignites during target disassembly
	UP-FI-001 – Fire due to combustible materials, flammable materials, or electrical short in UREX process box
	UP-FI-002 – Fire spreads to UREX process box
	UP-FI-003 – Fire/explosion from formation of red oil in TBP/dodecane
	WP-FI-001 – Fire due to combustible materials or electrical short in waste packaging box
	WP-FI-002 – Fire spreads to waste packaging box
	WS-FI-001 – Fire due to combustible materials or electrical short in waste storage canyon
	WS-FI-002 – Fire spreads to waste storage canyon
Other events	DB-RS-001 – Nitric acid solution spill in dissolver box
	PB-RS-001 – Chemical solution spill in purification box
	PX-RS-001 – Chemical solution spill in packaging box or during transfer to the HCF high bay
	UP-RS-001 – Chemical solution spill in UREX process box
	WP-RS-001 – Chemical solution spill in waste packaging box

Abbreviations: ISA = Integrated Safety Analysis | UREX = uranium extraction | SNM = special nuclear material | TBP tributyl phosphate

13b.A.4 REFERENCES

AIChE, 1992. Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples, American Institute of Chemical Engineers, 1992.

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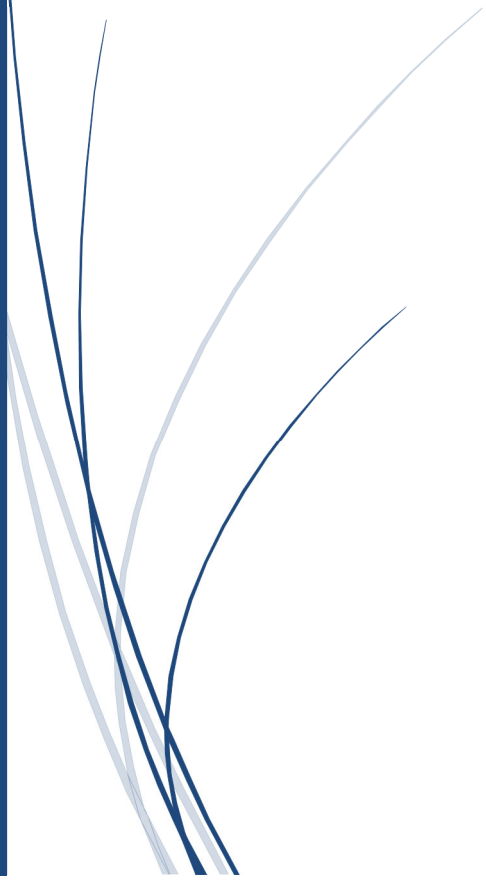

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Chapter 14a
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CHAPTER 14a
REACTOR FACILITY TECHNICAL SPECIFICATIONS

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
EMIF	Eden Medical Isotope Facility
LCO	limiting condition for operation
LSSS	limiting safety system setting
PSAR	Preliminary Safety Analysis Report
RF	Reactor Facility
SL	safety limit
TS	technical specification(s)

14a. Reactor Facility Technical Specifications

14a.1 INTRODUCTION

This section encompasses the technical specifications (TS) for the processes involving special nuclear material and radioisotopes inside the Reactor Facility (RF).

In accordance with the requirements of Title 10 of the Code of Federal Regulations (10 CFR) 50.34 (a)(5), this section identifies the variables and conditions that are likely subjects of TS for the Eden Medical Isotope Facility (EMIF). These variables and conditions are based on the preliminary design of the EMIF. These are subject to change in the Operating License Application.

The TS will be submitted with the Operating License Application. These proposed variables have been identified on the premise that this material presents a sound framework upon which a final, complete set of TS can be provided with the Operating License Application.

The format and content of the TS are written using the guidance provided in American National Standards Institute (ANSI)/American Nuclear Society (ANS) ANSI/ANS 15.1-2007, The Development of Technical Specifications for Research Reactors (R2018) (ANSI/ANS, 2018). The TS for non-power reactors include the categories in 10 CFR 50.36 for production and utilization facilities.

Definitions will be provided in the application for an Operating License (see Table 14a.1-1).

Table 14a.1-1
(Sheet 1 of 4)
Reactor Facility Proposed Parameters for Technical Specifications

Application Section Per ANSI/ANS 15.1-2007 (ANSI/ANS, 2018)	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
1	**Definitions**		
The definitions based on ANSI/ANS 15.1-2007 will be provided in the application for an Operating License (ANSI/ANS, 2018).			
2	**Safety Limits and Limiting Safety System Settings**		
2.1	Target Element Safety Limits	• Fuel cladding temperature.	• 4a.6.7 • 13a.2
2.2	Limiting Safety System Settings	• High reactor power scram. • Core coolant inlet temperature scram.	• 4a.5 • 4a.6 • 13a.2
3	**Limiting Conditions for Operations**		
3.1	Reactor Core Parameters	Core parameter limits will be established for the following: • Maximum excess reactivity. • Shutdown margin. • Core arrangement requirements. • Fuel (target) burnup.	• 4a.5

Table 14a.1-1
(Sheet 2 of 4)
Reactor Facility Proposed Parameters for Technical Specifications

Application Section Per ANSI/ANS 15.1-2007 (ANSI/ANS, 2018)	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
3.2.1	Reactor Control and Safety Systems	Minimum number of operable control rods will be specified in the application for an Operating License.	• 4a.5
3.2.2	Reactor Control and Safety Systems	Maximum reactivity insertion rate will be specified in the application for an Operating License.	• 13a.2
3.2.3	Reactor Control and Safety Systems	Maximum reactivity insertion for pulsed operation is not applicable.	N/A
3.2.4	Reactor Control and Safety Systems	Minimum scram channels: • High power scram. • Reactor period scram. • Core inlet temperature scram. • Reactor pool water level scram. • Reactor control room manual scram.	• 7a.4 • 13a.2
3.2.5	Reactor Control and Safety Systems	Minimum channels needed for reactor operation: • Power range nuclear instrumentation. • Wide range nuclear instrumentation. • Core inlet temperature. • Reactor pool water level.	• 7a.4
3.2.6	Reactor Control and Safety Systems	Minimum required interlocks: • Control rod drive vernier indication. • Safety rod up and down limit switches. • Safety rod withdrawal interlock. • Control rod withdrawal interlock. • Minimum count rate interlock.	• 7a.3 • 13a.2
3.2.7	Reactor Control and Safety Systems	Backup shutdown mechanisms is not applicable.	N/A

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Table 14a.1-1
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Reactor Facility Proposed Parameters for Technical Specifications

Application Section Per ANSI/ANS 15.1-2007 (ANSI/ANS, 2018)	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
3.2.8	Reactor Control and Safety Systems	Permitted bypassing will be specified in the application for an Operating License.	• 7a.2
3.3	Reactor Coolant System	• Reactor pool water level. • Secondary side radioactivity limit. • Reactor coolant conductivity.	• 5a.2 • 5a.3 • 13a.2
3.4	Containment or Confinement	Confinement requirements to meet ALARA objectives will be specified in the application for an Operating License.	• 6a.2
3.5	Ventilation Systems	Ventilation system requirements to meet ALARA objectives will be specified in the application for an Operating License.	• 9a.1
3.6	Emergency Power	Not applicable. There are no credited features for the RF that require emergency power.	N/A
3.7	Radiation Monitoring Systems and Effluent Control	The following radiation monitors are required to be operable: • RF high bay general area radiation. • Reactor pool general area radiation. • Exhaust stack general area radiation. • Cleanup loop general area radiation. • RF high bay airborne radiation. • Reactor pool airborne radiation. • Exhaust stack airborne radiation.	• 7a.7 • 13a.2
3.8	Experiments	Not applicable. The RF does not include experiments.	N/A
3.9	Facility Specific LCOs	Facility specific LCOs, if any, will be identified as part of the Operating License Application.	N/A

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Table 14a.1-1
(Sheet 4 of 4)
Reactor Facility Proposed Parameters for Technical Specifications

Application Section Per ANSI/ANS 15.1-2007 (ANSI/ANS, 2018)	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
4	**Surveillance Requirements**		
Surveillance requirements relating to test, calibration, or inspection to ensure the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that LCOs will be met will be provided in the application for an Operating License.			
5	**Design Features**		
Design features include those features of the facility, such as materials of construction and geometric arrangements, that if altered or modified could have a significant effect on safety. Design features will be provided in the application for an Operating License.			
6	**Administrative Controls**		
Administrative controls are the programmatic provisions relating to organization and management, procedures, recordkeeping, review and audit, and reporting necessary to ensure operation of the facility in a safe manner. Administrative controls will be provided in the application for an Operating License.			

Abbreviations: ANSI/ANS = American National Standards Institute/American Nuclear Society | PSAR = Preliminary Safety Analysis Report | N/A = not applicable | ALARA = As Low As Reasonably Achievable | RF = Reactor Facility | LCO = limiting condition for operation

14a.2 SAFETY LIMITS AND LIMITING SAFETY SETTINGS

Safety limits (SLs) are placed on important process variables as necessary to prevent the uncontrolled release of radioactivity.

Limiting safety system settings (LSSSs) are settings for automatic protective devices related to those variables having significant safety functions. These settings ensure that automatic protective action corrects the abnormal situation before an SL is exceeded. Refer to Table 14a.1-1 for the SLs and LSSSs associated with the RF. The justifications for the variables chosen are given in the sections/subsections listed in Table 14a.1-1.

14a.3 LIMITING CONDITIONS FOR OPERATION

Limiting conditions for operation (LCOs) are derived from the safety analyses and are implemented administratively or by control and monitoring circuitry to ensure safe operation of the RF. The LCOs are the lowest functional capability or performance level required for safe operation of the RF.

Table 14a.1-1 shows LCOs associated with the RF. The justifications for the variables chosen are provided in the sections listed in the table.

14a.4 SURVEILLANCE REQUIREMENTS

Surveillance requirements are provided in the TS (see Table 14a.1-1).

14a.5 DESIGN FEATURES

Design features that are provided in the TS are the features of the EMIF RF, such as materials of construction and geometric arrangements, that would have a significant effect on safety if these features were altered or modified (see Table 14a.1-1).

14a.6 ADMINISTRATIVE CONTROLS

Administrative controls are provided in the TS (see Table 14a.1-1).

14a.7 REFERENCES

ANSI/ANS, 2018. The Development of Technical Specifications for Research Reactors, ANSI/ANS 15.1-2007 (R2018), American National Standards Institute, American Nuclear Society, approved 2007, reaffirmed 2018.

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CHAPTER 14b
HOT CELL FACILITY TECHNICAL SPECIFICATIONS

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ANS	American Nuclear Society
ANSI	American National Standards Institute
CAAS	criticality accident alarm system
CFR	Code of Federal Regulations
HCF	Hot Cell Facility
ISG	Interim Staff Guidance
LCO	limiting condition for operation
LSSS	limiting safety system setting
PSAR	Preliminary Safety Analysis Report
SL	safety limit(s)
SNM	special nuclear material
TS	technical specification(s)

14b. Hot Cell Facility Technical Specifications

14b.1 INTRODUCTION

The technical specifications (TS) for special nuclear material (SNM), radiochemical, and chemical processing conducted outside of the Reactor Facility are derived from the accident analyses described in Chapter 13b. The analyses of these processes indicates that certain limits on process variables and engineered or administrative control measures may become necessary to demonstrate safe operation of the Hot Cell Facility (HCF). Certain engineered or administrative control measures are listed in these TS as part of the Operating License Application to ensure that they are available and reliable to perform their intended functions if needed.

The format and content of the TS for radiochemical, chemical, and SNM processing outside of the reactor are presented in Table 14b.1-1. The assignment of TS for the HCF comply with the regulations in Title 10 of the Code of Federal Regulations (10 CFR) 50.36 for a radioisotope separation facility. Safety limits (SLs) and control setpoints are placed on those process variables that, if breached, would lead to the uncontrolled release of radioactive material.

Table 14b.1-1
(Sheet 1 of 4)
Hot Cell Facility Proposed Parameters for Technical Specifications

ISG Augmenting NUREG-1537[(a)]	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
1	**Definitions**		
The definitions based on ANSI/ANS 15.1-2007 will be provided in the application for an Operating License (ANSI/ANS, 2018).			
2	**Safety Limits and Limiting Safety System Settings**		
2.1	Safety Limits for Processing Special Nuclear Material Outside of the Reactor	For irradiated SNM outside of the reactor, SLs are derived for criticality accident prevention based on the Nuclear Criticality Safety Program and from the accident analyses described in Chapter 13b. Limits are set with a conservative margin.	• 4b.4 • 13b.2
2.1	Safety Limits for Processing Unirradiated Special Nuclear Material Outside of the Reactor	Limits are specified, using the double-contingency principle, to avoid a criticality accident. Limits are set with a conservative margin.	• 4b.4 • 6b.5 • 13b.2
2.1	Safety Limits for Radiochemical Processing	SLs for radiochemical processing are developed to maintain operations within limits pursuant to 10 CFR 50.36 to protect the worker and the public. The amount of radiation is limited so as not to exceed the shielding and confinement capabilities of the systems and components in which the materials are processed or stored.	• 4b.3 • 13b.3

Table 14b.1-1
(Sheet 2 of 4)
Hot Cell Facility Proposed Parameters for Technical Specifications

ISG Augmenting NUREG-1537[(a)]	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
2.1	Safety Limits for Chemical Processing	SLs for chemical processing with hazardous chemicals that are conducted coincident with operations with SNM or radioactive material are developed in accordance with 10 CFR 50.36.	• 4b.3 • 13b.3
2.2	Limiting Safety System Settings	For each process variable or parameter for which a SL is specified, and for which monitoring instruments are used, a protective operating limit is set to avoid exceeding the SL. This LSSS is calculated to provide a conservative margin below the SL and to account for overall measurement uncertainty, operating characteristics of control systems, and accuracy of control instrumentation.	• 4b.3 • 4b.4
3	**Limiting Conditions for Operations**		
3.1	Primary Process Components and Systems	Processing structures, systems, and components and procedures are designed and constructed to ensure that processing is conducted safely and will have LCOs established in the application for an Operating License.	• 4b.1 • 13b.2 • 13b.3
3.2	Containment and Confinement	Steel confinement boxes 2-7 will have LCOs established in the application for an Operating License. (See Ventilation Systems below)	• 6b.2 • 13b.2

Table 14b.1-1
(Sheet 3 of 4)
Hot Cell Facility Proposed Parameters for Technical Specifications

ISG Augmenting NUREG-1537[(a)]	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
3.3	Ventilation Systems	HCF Zone 1a portion of the HCF ventilation system LCOs will be identified as part of the Operating License Application.	• 6b.2 • 13b.2
3.4	Emergency Electrical Power	Uninterruptible power supply system for HCF Zone 1a fans, dampers, and instrumentation LCOs will be identified as part of the Operating License Application.	• 6b.2 • 8.3
3.5	Radiation Monitoring Systems and Effluents	The following radiation monitors are required: • General area radiation monitor measuring channels. • General area continuous air monitoring measuring channels. • HCF exhaust stack(s) effluent air monitor measuring channels. The radiation monitors LCOs will be identified as part of the Operating License Application.	• 7b.7
-	Facility Specific LCOs	Facility specific LCOs, if any, will be identified as part of the Operating License Application.	N/A

Table 14b.1-1
(Sheet 4 of 4)
Hot Cell Facility Proposed Parameters for Technical Specifications

ISG Augmenting NUREG-1537[(a)]	Section Name	Description of Safety Limit, Limiting Safety System Setting, Limiting Condition for Operation, Design Feature, or Administrative Control	Basis: PSAR Subsection
4	**Surveillance Requirements**		
Surveillance requirements relating to test, calibration, or inspection to ensure the necessary quality of systems and components is maintained, that facility operation will be within SLs, and that LCOs will be met, will be provided in the application for an Operating License.			
5	**Design Features**		
Design features include those features of the facility, such as materials of construction, geometric arrangements, and the CAAS, that if altered or modified could have a significant effect on safety. Design features will be provided in the application for an Operating License.			
6	**Administrative Controls**		
Administrative controls are the programmatic provisions relating to organization and management, procedures, recordkeeping, review and audit, and reporting necessary to ensure operation of the facility in a safe manner. Administrative controls will be provided in the application for an Operating License.			

a) Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors

Abbreviations: ISG = interim staff guidance | PSAR = Preliminary Safety Analysis Report | ANSI/ANS = American National Standards Institute/American Nuclear Society | SNM = special nuclear material | SL = safety limit | CFR = Code of Federal Regulations | LSSS = limiting safety system setting | LCO = limiting condition for operation | HCF = Hot Cell Facility | N/A = not applicable | CAAS = criticality accident alarm system

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14b.2 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

The SL and limiting control settings are derived from the accident analyses described in Chapter 13b. They are primarily engineered controls that are put in place to ensure that operations are maintained within adequate margins of safety.

For each process variable or parameter for which an SL is specified and for which monitoring instruments are employed, a protective operating limit is set to avoid exceeding the SL. This setpoint is calculated to provide a conservative margin below the SL and to account for overall measurement uncertainty, operating characteristics of control systems, and accuracy of control instrumentation.

Refer to Table 14b.1-1 for the SLs and limiting safety system settings (LSSSs) associated with the HCF. The justifications for the variables chosen are given in the section/subsection listed in Table 14b.1-1. The actual variables for the SLs and LSSSs will be provided in the application for an Operating License.

14b.3 LIMITING CONDITIONS OF OPERATION

Limiting conditions for operation (LCOs) are derived from the accident analyses described in Chapter 13b. They are administrative or engineered controls in addition to LSSSs that are put in place to ensure that operations are maintained within safe limits.

14b.4 SURVEILLANCE REQUIREMENTS

Surveillance requirements for any of the LSSSs and LCOs listed in the previous sections pertaining to the processing of SNM, radioactive materials, and hazardous chemicals must be established and are listed as a TS pursuant to 10 CFR 50.36(c)(3). Surveillance requirements should exist for the LSSSs and LCOs in the following categories:

- Process control instrumentation.
- Process cooling systems.
- Process containment/confinement systems.
- Process-related ventilation systems.
- Emergency power supplies.
- Radiation monitoring systems.

14b.5 DESIGN FEATURES

Design features that are provided in the TS are the features of the Eden Medical Isotope Facility HCF, such as materials of construction, geometric arrangements, and the criticality accident alarm system that would have a significant effect on safety if these features were altered or modified (see Table 14b.1-1).

14b.6 ADMINISTRATIVE CONTROLS

Administrative controls are provided in the TS (see Table 14b.1-1).

14b.7 REFERENCES

ANSI/ANS, 2018. The Development of Technical Specifications for Research Reactors, ANSI/ANS 15.1-2007 (R2018), American National Standards Institute, American Nuclear Society, approved 2007, reaffirmed 2018.

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Chapter 15
Financial Qualifications

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CHAPTER 15
FINANCIAL QUALIFICATIONS

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None.

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
CFR	Code of Federal Regulations
CPA	Construction Permit Application
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
FQ	Financial Qualification
Lu-177	leutetium-177
Mo-99	molybdenum-99
NRC	U.S. Nuclear Regulatory Commission
Tc-99m	technetium-99m

15 Financial Qualifications

The U.S. Nuclear Regulatory Commission (NRC) has set forth requirements for applicants for a Construction Permit pursuant to Title 10 of the Code of Federal Regulations (10 CFR) 50.33(f) to submit sufficient information to demonstrate that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction costs and related fuel cycle costs, including the source(s) of funds to cover these costs.

Appendix C to 10 CFR 50 provides financial guidelines and distinguishes between applicants that are established organizations and those that are newly-formed entities organized primarily for the purpose of engaging in the activity for which the permit is sought. Appendix C provides a guide for the financial data and related information required to establish financial qualifications for Construction Permits.

Eden Radioisotopes, LLC (Eden) is considered a newly-formed entity. As stated in Appendix C, the information required by the NRC that will normally be required of applicants which are newly-formed entities, and specific to construction cost estimates, will not differ in scope from that required of established organizations.

Enclosure 4 of the Eden Construction Permit Application (CPA) letter (Eden-NRC-2026-002) provides Eden's request for an exemption pursuant to 10 CFR 50.12 that would allow Eden to apply the financial qualification provisions in 10 CFR 70.23(a)(5) for applicants under 10 CFR Part 70, requiring “that the applicant appears to be financially qualified…” (Part 70 Financial Qualification [FQ] Requirements), in lieu of the construction financial qualification requirements in 10 CFR 50.33(f) and 10 CFR Part 50, Appendix C. Specifically, Eden requests that it be permitted to demonstrate that it “appears to be financially qualified” for the issuance of a construction permit under the review standard defined in Section 7 of the Part 70 Review Standard, Financial Qualifications for Reactor Licensing Rulemaking (NRC 2016a). To satisfy the Part 70 FQ Requirements under the Part 70 Review Standard, Section 15.1, below, contains both a construction cost estimate and a financial capacity plan.

15.1 FINANCIAL ABILITY TO CONSTRUCT A NON-POWER REACTOR

Eden Radioisotopes, LLC is a New Mexico limited liability company with an address of 9400 Holly Ave. NE, Suite 202 Albuquerque, NM 87122. Eden is majority owned by Abo Empire, whose roots are in oil and gas. Today, Abo Empire's mission is to invest in companies with the potential to positively and significantly impact New Mexico's economic development. Abo Empire, in turn, is owned by the Yates Family. In 2015, Forbes Magazine ranked the family's net worth at $2.5 billion, making it one of the 115 richest in the nation.

The construction cost estimate described below coupled with the discussion of the Eden outreach program and qualifications of the Eden Leadership Team and key strategic advisory team members demonstrates Eden’s financial capacity to obtain the necessary funding for the Eden Isotope Production Complex (EIPC) construction and as such are intended to support a determination that the 10 CFR 70.23(a)(5) “appears to be financially qualified” requirement is met under the requested exemption.

Construction Cost Estimate

Presented below are estimates which represent the combined cost projections (as of December 2025) for the construction of the EIPC.

Complete construction of the facility	$[[ ]]PROP
Equipment costs	$[[ ]]PROP
Target (fuel) costs for first year of operation	$[[ ]]PROP
TOTAL ESTIMATED COST	$[[ ]]PROP

Financial Capacity Plan

As of December 2025, Eden has raised approximately $22 million in equity investment from Abo Rad, LLC, an investment fund of the Yates family office of New Mexico.

The Eden outreach process includes researching and exploring investment interest from strategically aligned operating companies in the clinical radioisotope, biopharmaceutical, and nuclear sectors as well from established institutional and large family office investors who have formerly invested in projects of similar scope and segment as the Eden project.

There are active discussions advancing with several potential lead investors and with several others who have expressed intent to co-invest once a lead investor is established.

In addition, ongoing offtake discussions are underway with potential end use customers, which, when memorialized in one or more offtake agreements, are expected to promote further interest in the Eden facility investment.

To further promote the opportunity for equity investment, Eden has retained the services of Agenda Global. Agenda is an entrepreneurial public affairs firm delivering creative, responsive, and effective integrated communications, advocacy, and engagement programs for corporate, government and international organizations.

The Eden Leadership Team spans 30 – 50 years in nuclear medicine, reactor engineering, and NRC licensing, with pedigrees from Nordion, Mallinckrodt Pharmaceuticals, Sandia National Laboratories, Bechtel and the NRC.

To further strengthen its capability, the team has partnered with the following companies, who have considerable experience and knowledge of established institutional and large family office investors.

Cross River Industry Partners – Cross River Infrastructure Partners is a private infrastructure development firm focused on decarbonization, energy transition, and industrial project development in North America. Cross River Infrastructure Partners develops critical infrastructure across energy, digital, and healthcare sectors. Its mission is to design and deliver transformative projects that align advanced energy systems, sovereign digital capacity, and essential medical technologies to build more sustainable, resilient communities and global supply chains.

Solestiss – Solestiss is a women-owned company which provides project development and advisory services to nuclear value chain suppliers, investors and project owners. Solestiss

possesses extensive expertise in the nuclear sector and the broader energy ecosystem, which is invaluable for market studies, developing commercialization strategies for new technologies, and conducting technology evaluations.

The Eden Leadership Team is also supplemented by several key strategic advisors, most notably:

Jigar Shah – Mr. Shah is an entrepreneur who served as the director of the Loan Programs Office in the U.S. Department of Energy from March 2021 to January 2025.

Nella Domenici – Ms. Domenici is a public company Board Director, CFO, COO, and an expert in governmental affairs. She has held leadership positions in technology, AI, and financial services, bringing deep executive and operational experience to cutting-edge companies.

Presently, additional funding from Abo Rad, LLC beyond their equity investment to date is also under active consideration to move the project into the construction permitting phase until full financing from institutional investors is secured.

The goal is to complete financing of the construction phase of the project during CY2026. However, because Eden does not have, at the time of submitting the CPA, committed funding sources of more than 50 percent of the total estimated cost of construction, Eden proposes that the following license condition be included in the EIPC construction permit:

The licensee will notify the NRC at least 60 days prior to its anticipated date of construction that the license condition has been fulfilled and that the following are available for inspection:

- An updated cost estimate.
- Documentation justifying any variances from the original cost estimate provided in the application.
- Documentation demonstrating that the licensee has secured financing to meet the updated cost estimate for the project, including closing documents or documented proof of parent and affiliate assurances, or capital from other sources that reflect financing for the project.

This proposed license condition is identical, verbatim, to the example license condition specified in Section 7.2.2.1 of the Part 70 Review Standard (NRC, 2016a) , and functionally identical to license condition 2.D.(14)(k)1, as approved by the Commission in issuing the combined operating licenses for South Texas Project, Unit 3 (NRC, 2016b) and Unit 4 (NRC, 2016c).

Conclusion on Construction Financial Qualifications

The cost estimate and financial capacity plan above provide the NRC with adequate information to conclude that Eden appears to be financially qualified. This information reflects Eden’s level of understanding of the size and scope of the project, including the level of capital necessary to undertake the project, and it reflects the organizational and human resources, experience, skills, and expertise required to obtain proper financing and ultimately finance the project, before the start of reactor construction. Accordingly, Eden satisfies the Part 70 FQ Requirements under the Part 70 Review Standard.

15.2 FINANCIAL ABILITY TO OPERATE A NON-POWER REACTOR

A Class 103 operating license for a 40-year period pursuant to 10 CFR 50.22 (for commercial and industrial facilities), as well as future licenses for byproduct material under 10 CFR Part 30, source material under 10 CFR Part 40, and special nuclear material under 10 CFR Part 70, are expected to be the subjects of future applications.

Eden financial projections assume a 40-year operating period for the non-power medical isotope utilization and production facility.

Eden has reasonable assurance of obtaining the necessary funds to cover estimated facility operation costs for the period of the license. Operating costs for the facility are covered by the sustained sale of critical medical isotopes to radiopharmaceutical manufacturers, who manufacture United States Food and Drug Administration approved radiopharmaceuticals for patient diagnostic medical imaging and therapy.

Eden plans to produce Active Pharmaceutical Ingredient medical isotopes used in radiopharmaceutical manufacturing and medical imaging procedures worldwide. The primary medical isotope to be produced is molybdenum-99 (Mo-99). Mo-99 is the parent isotope that decays to technetium-99m (Tc-99m), which is the primary diagnostic imaging isotope used in nuclear medicine imaging procedures. Tc-99m is used in more than 80 percent of the 40 million nuclear medicine procedures performed annually worldwide. Eden also plans to produce other isotopes for diagnostic or therapeutic uses, most notably leutetium-177 (Lu-177). For purposes of the included financial projections, revenue from Mo-99 and Lu-177 sales are used.

Estimates of the total annual operating costs for each of the first five years of operation of the facility will be provided with the application for an Operating License consistent with 10 CFR 50.33(f)(2).

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15.3 FINANCIAL ABILITY TO DECOMMISSION THE FACILITY

Eden has reasonable assurance that funds will be available to decommission the facility in accordance with 10 CFR 50.33(k). This information is to be submitted to the NRC for decommissioning in accordance with 10 CFR 50.75(d)(1) as part of the application for an Operating License.

Eden will provide a preliminary site-specific decommissioning plan with estimated costs and financial assurances to support those costs in the application for an Operating License.

15.4 FOREIGN OWNERSHIP, CONTROL, OR DOMINATION

Eden Radioisotopes, LLC, is the applicant for the construction permit and subsequent operating license for the EIPC. Eden Radioisotopes, LLC, was created for the purpose of designing, constructing, and operating the EIPC for the production and marketing of radionuclides to the nuclear medicine community.

Eden Radioisotopes, LLC, is a privately-owned New Mexico business with a limited number of investors that solely own the company and its assets. Current investors are United States citizens or entities owned or controlled by United States citizens.

Eden Radioisotopes, LLC, is not owned, controlled, or dominated by an alien, a foreign corporation, or a foreign government. Eden is not acting as an agent or representative of another person in filing this application.

15.5 NUCLEAR INSURANCE AND INDEMNITY

Eden intends to obtain insurance and financial protection consistent with the requirements of the Price-Anderson Act, pursuant to Section 170 of the Atomic Energy Act of 1954, as amended, and the requirements in 10 CFR Part 140.

Prior to the issuance of the Operating License, Eden will obtain the full financial protection required by 10 CFR Part 140 using the formula provided in 10 CFR 140.12(b). The amounts of financial insurance required by 10 CFR 140.12(b) and documentation required by 10 CFR 140.15 will be provided with the application for an Operating License.

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15.6 REFERENCES

NRC, 2016a. Financial Qualifications for Reactor Licensing Rulemaking, RIN Number: 3150-AJ43, NRC Docket ID: NRC-2014-0161, ADAMS Accession No. ML15322A185, Regulatory Basis Document, U.S. Nuclear Regulatory Commission, October 2016.

NRC, 2016b. Combined License; South Texas Project Unit 3; Nuclear Innovation North America LLC; STP Nuclear Operating Company; NINA Texas 3 LLC; City of San Antonio, Texas, Acting by and through the City Public Service Board; Docket No. 52-012; License No. NPF-097, ADAMS Accession No. ML16033A020, U.S. Nuclear Regulatory Commission, February 2016.

NRC, 2016c. Combined License; South Texas Project Unit 4; Nuclear Innovation North America LLC; STP Nuclear Operating Company; NINA Texas 4 LLC; City of San Antonio, Texas, Acting by and through the City Public Service Board; Docket No. 52-013; License No. NPF-098, ADAMS Accession No. ML16033A047, U.S. Nuclear Regulatory Commission, February 2016.

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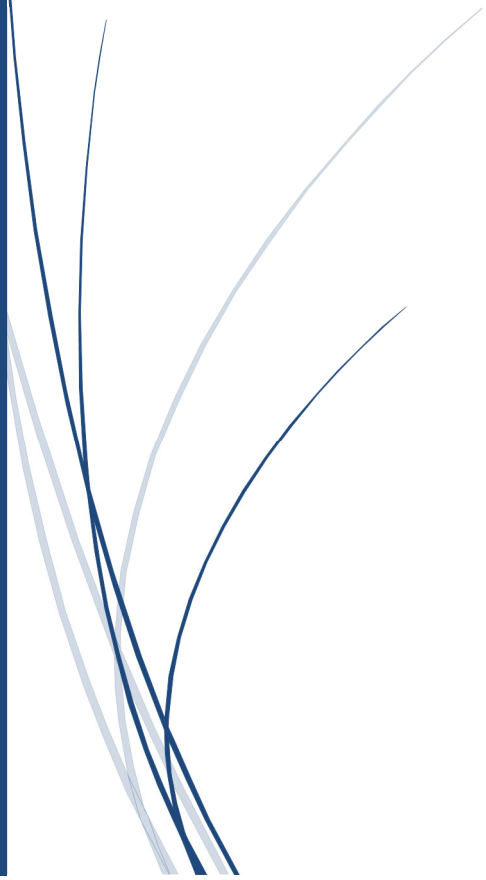
Chapter 16
Other License Considerations



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None.

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
EIPC	Eden Isotope Production Complex

16 Other License Considerations

16.1 PRIOR USE OF REACTOR COMPONENTS

The Eden Isotope Production Complex (EIPC) utilizes new and appropriately-qualified components and systems to conduct production operations. Discussions regarding used components and systems are not applicable to the EIPC.

16.2 MEDICAL USE OF NON-POWER REACTORS

The EIPC does not contain equipment or facilities associated with direct medical administration of radioisotopes or other radiation-based therapies. Therefore, discussions involving medical use of the EIPC are not applicable.

16.3 REFERENCES

None.

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Chapter 17
Decommissioning and Possession-Only License Amendments

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CHAPTER 17

DECOMMISSIONING AND POSSESSION-ONLY LICENSE AMENDMENTS

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None.

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
CFR	Code of Federal Regulations

17 Decommissioning and Possession-Only License Amendments

17.1 DECOMMISSIONING

A decommissioning report for the facility will be submitted in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.33(k)(1) with the Operating License Application. The report will address the content requirements of 10 CFR 50.75(d)(2). Section 15.3 describes the financial assurance for the availability for funding to support decommissioning.

17.2 POSSESSION-ONLY LICENSE AMENDMENT

This section relates to a possession-only license and is not applicable to the Eden Isotope Production Complex.

17.3 REFERENCES

None.

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Chapter 18
Highly Enriched to Low-Enriched Uranium Conversions

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CHAPTER 18
HIGHLY ENRICHED TO LOW-ENRICHED URANIUM CONVERSIONS

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition

None.

18 Highly Enriched to Low-Enriched Uranium Conversions

18.1 HIGHLY ENRICHED TO LOW-ENRICHED URANIUM CONVERSION

This chapter does not apply to the Eden Isotope Production Complex because it is a new facility that uses low-enriched uranium.

18.2 REFERENCES

None.

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Chapter 19
Environmental Report

Section 19.1
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CHAPTER 19
ENVIRONMENTAL REPORT

SECTION 19.1 INTRODUCTION

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None.

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
20.3 NMAC	New Mexico Radioactive and Hazardous Material Act
BR-2	Belgian Reactor 2
CERCA	Compagnie pour l'Etude et la Réalisation de Combustibles Atomiques
CFR	Code of Federal Regulations
Ci	curies
Ci/g	curies per gram
CNEA	Comisión Nacional de Energía Atómica (Argentina)
CNL	Canadian Nuclear Laboratories
CP	Construction Permit
CT	computed tomography
DHSEM	New Mexico Department of Homeland Security and Emergency Management
EA	Environmental Assessment
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EIS	Environmental Impact Statement
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Report
FAA	U.S. Federal Aviation Administration
FDA	U.S. Food and Drug Administration
FMCSA	U.S. Department of Transportation Federal Motor Carrier Safety Administration
GEP-NET	gastroenteropancreatic neuroendocrine tumor
HCF	Hot Cell Facility

Acronym/Abbreviation	Definition
HEU	highly enriched uranium
HFR	High-Flux Reactor
I-131	iodine-131
ISG	Interim Staff Guidance
km	kilometer(s)
LEU	low-enriched uranium
Lu-177	lutetium-177
LUTATHERA®	Trade name of medicine: lutetium Lu-177 dotatate
LVR-15	Lehkovodní Reaktor - 15 (Czech Republic)
mi.	mile(s)
Mo-98	molybdenum-98
Mo-99	molybdenum-99
MRI	magnetic resonance imaging
MURR®	University of Missouri Research Reactor
$NaTcO_4$	sodium pertechnetate
NEA	Nuclear Energy Agency
NEA HLG-MR	Nuclear Energy Agency High-Level Group on Security of Supply of Medical Radioisotopes
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act
NM	New Mexico (United States of America)
NMAC	New Mexico Administrative Code
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMRLD/CID	New Mexico Regulation and Licensing Department – Construction Industries Division

Acronym/Abbreviation	Definition
NMSA	New Mexico Statutes Annotated
NOAA	U.S. National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NorthStar	NorthStar Medical Radioisotopes, LLC
NRC	U.S. Nuclear Regulatory Commission
NRU	Canada's National Research Universal
NTP	Nuclear Technology Products
OECD – NEA	Organization for Economic Cooperation and Development – Nuclear Energy Agency
OL	Operating License
OPAL	Open Pool Australian Lightwater Reactor
PSMA	prostate-specific membrane antigen
PSTB	Petroleum Storage Tank Bureau
Public Law 101-601; 25 U.S.C. 3001-3013	Native American Graves Protection and Repatriation Act
RF	Reactor Facility
RLT	radioligand therapy
SAFARI-1	South African Fundamental Atomic Research Installation 1
SARA	Superfund Amendments and Reauthorization Act
SNM	Special Nuclear Material
SPCC	Spill Prevention Control and Countermeasure
SSTR2	somatostatin receptor subtype 2
SWPPP	Stormwater Pollution Prevention Plan
Tc-99m	technetium-99m

Acronym/Abbreviation	Definition
U.S.	United States (of America)
U.S.C.	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
U-235	uranium-235
Xe-133	xenon-133

19 Environmental Report

19.1 INTRODUCTION

In accordance with the provisions of Title 10 (*Energy*) of the Code of Federal Regulations (CFR) Part 50, Domestic Licensing of Production and Utilization Facilities (10 CFR Part 50) and supporting guidance, Eden Radioisotopes, LLC (Eden) is providing this Environmental Report (ER) in support of its application to the United States (U.S.) Nuclear Regulatory Commission (NRC) for a Construction Permit (CP) to construct the Eden Isotope Production Complex (EIPC) near Eunice, New Mexico (NM). The EIPC produces molybdenum-99 (Mo-99), iodine-131 (I-131), and xenon-133 (Xe-133) through the fission process and produces other isotopes, such as lutetium-177 (Lu-177), through neutron activation. The decay product of Mo-99, technetium-99m (Tc-99m), is used for a variety of nuclear medicine diagnostic procedures.

Eden has prepared this ER to meet the requirements specified in 10 CFR Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, Subpart A, National Environmental Policy Act-Regulations Implementing Section 102(2), including the general ER requirements set forth in 10 CFR 51.45. The ER serves two primary purposes. First, it provides information that is specifically required by the NRC to assist the agency in meeting its obligations under the National Environmental Policy Act of 1969 (NEPA) and the agency's NEPA-implementing regulations at 10 CFR Part 51. Second, information and data provided in the ER demonstrate that the environmental protection measures proposed by Eden are adequate to protect both the environment and the health and safety of the public.

The EIPC site center is located in Lea County, NM, approximately 1.4 miles (mi.) (2.2 kilometers [km]) east of the Eunice, NM, boundary, and approximately 1.9 mi. (3.1 km) west of the Texas–New Mexico border. As described in more detail in Section 19.2.1 of this ER, the facility consists of a Reactor Facility (RF), which includes a small, non-power, open-pool reactor facility, and a separation processing Hot Cell Facility (HCF), which includes a target fabrication area, and waste packaging, handling, and storage areas. In addition to the RF and HCF, administrative and storage areas are provided. A preliminary general arrangement drawing of the EIPC and site layout is provided in ER Section 19.2.1, Figure 19.2.1-4.

The ER follows the content and organization described in the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors, Chapter 19, and supports the regulatory review performed by the NRC under 10 CFR Part 51, which requires that environmental impacts from the project be evaluated and described in a concise, clear, and analytical manner. The ER includes an analysis that identifies the environmental impacts of the proposed action, including direct, indirect, and cumulative effects, as well as a comparison with environmental effects of alternatives to the proposed action. The ER discusses the existing environment at the Eunice, NM, site (referred to as the EIPC), the existing environmental and socioeconomic conditions in the vicinity of the EIPC, and assesses the environmental and socioeconomic impacts of construction, operation, and decommissioning of the facility. In addition, the ER considers appropriate impact mitigation measures and evaluates alternative sites and isotope production technologies. Eden prepared this ER to provide detailed information to the NRC in order to facilitate preparation of an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) in accordance with the provisions of 10 CFR Part 51, Subpart A.

19.1.1 PURPOSE AND NEED FOR PROPOSED ACTION

As set forth in Section 19.2.1 of this ER, the proposed federal action is the issuance of a CP by the NRC pursuant to the provisions of 10 CFR Part 50 that would authorize Eden to construct the EIPC for the production of Mo-99, I-131, and Xe-133 through the fission process and other isotopes, such as Lu-177 through neutron activation at the proposed EIPC located near Eunice, NM. The issuance of the CP is a separate licensing action from the issuance of an Operating License (OL) under 10 CFR Part 50 and a license to receive, possess, and use special nuclear material (SNM) for processes, including the fabrication of low-enriched uranium (LEU) targets under 10 CFR Part 70. A supplement to the ER will be submitted with an application for an OL and a license to receive, possess, and use SNM. However, EIPC operation and decommissioning and target fabrication are connected actions to issuance of the CP and are, therefore, addressed in this ER.

The purpose and need for this proposed action is to provide a medical isotope production option that would meet the need for a reliable domestic source of medical isotopes available to the medical community. Medical isotopes, including I-131, Xe-133, and Tc-99m, a daughter product of Mo-99, are used extensively for diagnostic medical procedures. Lu-177 is a therapeutic isotope used currently in the treatment of prostate and neuroendocrine cancers and potentially for other cancers in the future, as there are several dozen FDA clinical trials currently underway that use Lu-177. Information describing the need for a reliable domestic source of Mo-99, Lu-177 and the medical radioisotopes that are produced at the EIPC is provided in the following subsections.

19.1.1.1 Background

Nuclear medicine is a medical specialty that utilizes radioactive isotopes, referred to as radionuclides, for both diagnostic and therapeutic procedures. Radionuclides can be incorporated into radiopharmaceuticals and introduced into the body by injection, swallowing, or inhalation. After intake, the function, or physiology, of various tissues, organs, or organ systems can be demonstrated and quantified relative to the pharmacological properties of the specific radiopharmaceutical used (OECD – NEA, 2025). Diagnostic procedures using radioisotopes have become routine, as over 10,000 hospitals worldwide use radioisotopes in medicine, with about 90 percent of the radioisotope procedures being used for diagnosis (WNA, 2021).

Nuclear medical diagnostic imaging is part of a broader set of imaging modalities, including plain film x-ray, x-ray fluoroscopy, computed tomography (CT), ultrasound, and magnetic resonance imaging (MRI) (OECD – NEA, 2025). However, radionuclide imaging is unique when compared with other imaging modalities, as radionuclide imaging can be used to show active biological function, perfusion, or cellular viability of bone or tissue in the body, and nuclear medicine procedures can often detect the physiological and metabolic changes associated with disease before any anatomical changes occur (NAS, 2016). In using radionuclides for diagnosis, a radioactive dose is given to the patient and the activity in the organ can then be studied either as a two-dimensional picture or, using tomography, as a three-dimensional picture. Diagnostic techniques in nuclear medicine use radioactive tracers that emit gamma rays from within the body. These tracers are generally short-lived isotopes linked to chemical compounds that permit specific physiological processes to be scrutinized (WNA, 2021).

Radioisotopes are used by over 10,000 hospitals worldwide in medical procedures. About 90 percent of the procedures are for diagnosis, with Tc-99m being the most common radioisotope used. Approximately 40 million diagnostic procedures occur every year, accounting

for about 80 percent of all nuclear medicine procedures and 85 percent of diagnostic scans in nuclear medicine worldwide (WNA, 2021).

Historically, about half of these procedures have been performed in the United States (NAS, 2016). Other important radionuclides include I-131, Xe-133, and Lu-177. Xe-133 is used to image the distribution and rate of exchange of air in the lungs. Commonly used I-131 therapeutic agents include I-131-labeled sodium iodide, which is used for treating hyperthyroid disorders and thyroid cancer, and I-131-labeled metaiodobenzylguanidine, which is used for treating neuroblastomas and some cancers of the adrenal glands. Lu-177 has gained attention as a radiotherapeutic isotope, and in 2018, the U.S. Food and Drug Administration (FDA) granted approval for lutetium Lu-177 dotatate (LUTATHERA®) to be used specifically for treatment of gastroenteropancreatic neuroendocrine tumors (FDA, 2018a). A number of clinical trials have also shown the efficacy and clinical performance of ^{177}Lu-vipivotide tetraxetanmetastatic (PLUVICTO®) for prostate cancer, and this drug gained FDA approval in March 2022.

Tc-99m is a particularly useful imaging radionuclide because it emits energetic gamma rays (140 kiloelectron volts) that can be detected efficiently with widely available camera technologies; has a sufficiently long half-life (approximately 6 hours) to be usable in nuclear medicine procedures; provides low patient doses because of its short half-life and lack of alpha or beta radiations; and can be supplied efficiently to hospitals and clinics using technetium generators (NAS, 2016). Technetium generators are systems that store Mo-99 and allow its decay product, Tc-99m, to be recovered for use. A list of Tc-99m-based radiopharmaceuticals and clinical indications by organ system is provided in OECD – NEA, 2019. Tc-99m-based radiopharmaceuticals are used to diagnose disease in a large number of tissue and organ systems, such as bone, brain, kidneys, liver, lungs, and heart, including myocardial perfusion imaging, which images blood flow through heart muscle.

Despite significant progress made in oncology in treatments like chemotherapy, hormone therapy, radiotherapy and immunotherapy, there are still gaps in the needs of patients with rare, aggressive or late-stage cancers. Many existing therapies are insufficient to treat these cases, leaving a pressing need for innovative approaches to improve survival rates and quality of life (OECD – NEA, 2025).

Targeting cancers in tissues that lack a natural affinity for medical radioisotopes (like I-131 and radium-223 for thyroid and bone respectively) has become possible thanks to advances in molecular biology, which have enabled the development of ligands – molecules designed to bind specifically to proteins or receptors on cancer cells. Attaching a radioisotope to a ligand makes it possible to deliver radiation precisely to cancer cells, with the ligand acting as a "biological GPS." The technique of combining the precision of molecular targeting with the therapeutic power of radioisotopes is commonly referred to as radioligand therapy (RLT) (OECD – NEA, 2025).

Approvals of Lu-177 dotatate (Lutathera®) in 2018 for gastroenteropancreatic neuroendocrine tumors (GEP-NETs) and Lu-177 vipivotide tetraxetan (PLUVICTO®) in 2022 in the United States for metastatic castration-resistant prostate cancer highlight the growing clinical adoption of RLT. Both pharmaceuticals employ the beta-emitter Lu-177, which has become a cornerstone of RLT due to its ability to efficiently destroy tumors while sparing healthy tissue. GEP-NETs are characterized by high expression of somatostatin receptor subtype 2 (SSTR2), making them suitable targets for Lu-177-based therapy. This approach utilizes oxodotreotide (dotatate), a ligand that specifically binds to SSTR2, enabling targeted radiation delivery. Similarly, Lu-177

vipivotide tetraxetan is designed to treat metastatic castration-resistant prostate cancer by employing vipivotide tetraxetan (PSMA-617), which selectively binds to prostate-specific membrane antigen (PSMA) for precise radiopharmaceutical therapy. Efforts are also underway to develop therapies using other beta and alpha emitters, such as actinium-225, lead-212, and astatine-211, which deliver higher energy over a shorter range, making them ideal for treating micrometastases (OECD – NEA, 2025).

The global market for Lutetium-177 (Lu-177) radioligand therapy is projected to experience substantial growth by 2035, driven by the increasing adoption of targeted therapies for prostate cancer and neuroendocrine tumors. The market is forecasted to grow from roughly USD 3 billion in 2025 to over USD 35 billion by 2035.

Key Projections and Growth Drivers (by 2035):

- Specific Drug Growth: The market for PLUVICTO® (Lu-177 PSMA-617) is anticipated to grow significantly, potentially reaching USD 35.34 billion by 2035 (driven by high demand and expanded indications).
- Procedure Volume: The number of patients treated is expected to increase dramatically as PSMA-directed therapy becomes a standard, with potential for a multi-fold increase in global Lu-177 demand.
- Supply Chain: Manufacturing capacity for Lu-177 is scaling up, with expectations to support commercial supply through 2035 and beyond. It is important to note that the aging reactors used for Mo-99 target irradiations are also currently used for Lu-177 target irradiation. As these reactors age out and are decommissioned, irradiation capacity will also be challenged. The Eden reactor will add new capacity for as many as 3 million patient doses to help meet the future needs of the radiotherapeutic market.

Factors Driving Growth:

- Label Expansions: Increased product and indication approvals for using Lu-177 PSMA in earlier stages of prostate cancer, as well as other new cancer treatments.
- High Demand for Precision Oncology: The rise of theranostics—using the same molecule for both diagnosis (PET scan) and therapy.
- Clinical Success: Superior efficacy in reducing tumor size and improving survival rates in advanced, treatment-resistant cancers.
- Strategic Investments: Major acquisitions of and investment in biotech companies by large pharmaceutical firms (e.g., Novartis, Eli Lilly, Bristol Myers Squibb, AstraZeneca) and private capital are accelerating development.

Future Outlook:

- By 2035, Lu-177 based treatments are expected to be a fundamental pillar in oncology, with molecular radiotherapy potentially accounting for 60% of all radiation therapy procedures (Raitanen, et. al., 2023).

19.1.1.2 Mo-99 Production

There is no substitute for the diagnostic functional imaging provided through the use of Mo-99, Tc-99m, and other medical radioisotopes. Furthermore, almost all Tc-99m, the most common radioisotope used in nuclear medicine diagnostic procedures, is produced by radioactive decay of Mo-99. Mo-99 decays with a half-life of about 66 hours by emitting a beta particle. Approximately 88 percent of the decays produce Tc-99m (NAS, 2016).

Mo-99 can be produced by a number of processes. The primary production method is fission of uranium-235 (U-235). Using this method, Mo-99 is produced for medical use by irradiating targets containing uranium with neutrons produced by research reactors through the following reaction: U-235(n,f)Mo-99. In this reaction, fission of U-235 by irradiation with neutrons produces a double-hump distribution of fission products, with approximately 6.1 percent of the fissions resulting in the production of Mo-99. I-131 and Xe-133 are also uranium fission products produced at yields of approximately 3 percent and 6 percent, respectively (NAS, 2016). Uranium fission has been the preferred process for producing Mo-99 because the production process is highly efficient and the Mo-99 produced has a high specific activity (greater than 1000 curies per gram [Ci/g]), making it suitable for use in conventional technetium generators (NAS, 2016).

Mo-99 and Tc-99m can also be produced by irradiating natural molybdenum. In this reaction, molybdenum-98 (Mo-98) captures a neutron and transmutes to Mo-99 after emitting a gamma ray. In 2018, the FDA and NRC approved the use of NorthStar Medical Radioisotope, LLC's (NorthStar) RadioGenix™ System (now a registered trademark) for producing Tc-99m using this methodology (FDA, 2018b). NorthStar produced non-uranium-based Mo-99 in collaboration with the University of Missouri Research Reactor (MURR®), in Columbia, Missouri, using neutron-capture technology to convert naturally occurring Mo-98 to Mo-99 at the MURR® (Heltemes, 2020). However, in October 2023, NorthStar ceased production of Mo-99 and no longer offers the supply of Mo-99 to the market.

19.1.1.3 Mo-99 Production – Supply Chain and Production Capacity

The supply chain for Mo-99 production by irradiating targets containing U-235 generally involves: (1) Target suppliers that fabricate U-235 targets for Mo-99 production; (2) Irradiation service suppliers that irradiate U-235 targets to produce Mo-99; (3) Mo-99 suppliers that process irradiated targets to recover and purify Mo-99 for commercial sale; (4) Technetium generator suppliers that manufacture technetium generators for commercial sale; (5) Tc-99m suppliers that sell Tc-99m, sodium pertechnetate ($NaTcO_4$), and Tc-99m-labeled radiopharmaceuticals to end users; and (6) Tc-99m end users, including hospitals and clinics that purchase Tc-99m products for use in medical procedures (NAS, 2016).

19.1.1.3.1 Target Suppliers

A target contains U-235 (i.e., highly enriched uranium [HEU] or LEU) in a form that is suitable for irradiation in research reactors. In 2016, between approximately 9000 and 10,000 targets were being used annually to produce Mo-99 for medical use (NAS, 2016). Compagnie pour l'Etude et la Réalisation de Combustibles Atomiques (CERCA) in France was providing the majority of the targets used to produce Mo-99 by irradiating targets. Other target suppliers at the time included Comisión Nacional de Energía Atómica (CNEA), Argentina; Canadian Nuclear Laboratories (CNL), Canada; and Nuclear Technology Products (NTP) Radioisotopes, South Africa (NAS, 2016). CNL ceased operations in 2018. Unplanned extended outages and periods of reduced operating capacity at NTP beginning in November 2017 and into 2018, compounded

by short-term operating problems at multiple reactors in 2018, caused an extended chronic shortage of approximately 5 percent of the market demand for Mo-99 throughout much of 2018. Targets are not interchangeable among Mo-99 suppliers because of their unique designs, and it can take a year or more to obtain the uranium, manufacture it into the appropriate alloy form, and fabricate it into targets. Due to long lead times, most Mo-99 suppliers stockpile targets at target irradiation facilities. The National Academies of Sciences, Engineering, and Medicine has raised concerns about the vulnerability of the front end of the Mo-99 supply chain due to the limited number of target suppliers and because just one company provides a majority of the targets used to produce Mo-99 (NAS, 2018). The EIPC has the capability to produce its own targets.

19.1.1.3.2 Mo-99 Production

As of 2025, most of the global supply of fission-produced Mo-99 for medical use was provided by the High-Flux Reactor (HFR) in the Netherlands (6200 six-day Ci/week), South African Fundamental Atomic Research Installation 1 (SAFARI-1) in South Africa (3000 six-day Ci/week), the Open Pool Lightwater (OPAL) reactor in Australia (2150 six-day Ci/week), and Research Reactor in the Czech Republic, Lehkovodní reaktor (LVR-15) (3000 six-day Ci/week) (NAS, 2018). On a rotating frequency the Belgian Reactor 2 (BR-2) in Belgium (7800 six-day Ci/week) and Maria in Poland (1700 six-day Ci/week) serve to act as backup Mo-99 target irradiation support for the aforementioned reactors during their predetermined maintenance shutdown time periods.

Based on projected processing capacity estimates prepared by the Nuclear Energy Agency High-Level Group on Security of Supply of Medical Radioisotopes (NEA HLG-MR) published in December 2019, these six reactors are expected to continue to supply a majority of fission-produced Mo-99 through at least 2027 and beyond (NEA/NDC/R, 2023).

As Mo-99 cannot be inventoried due to its short half-life, any unplanned reactor outage can result in lost production and shortages of doses for patients. Mo-99 production has been disrupted on numerous occasions since 2009, some of which resulted in severe supply shortages in the United States. Disruptions in 2009 – 2010 occurred when Canada's National Research Universal (NRU) and Europe's HFR reactors were simultaneously shut down for extended periods (NRU has subsequently discontinued operations) (NAS, 2016). Supply interruptions have also occurred as a result of transportation denials and delays generally due to security concerns. For example, following the events of September 11, 2001, transportation of Mo-99 to the United States by air was halted (NAS, 2009).

Vulnerabilities also exist because the supply chain is designed to deliver Mo-99/Tc-99m on a weekly or more frequent basis. This type of delivery, known as "just-in-time" delivery, is essential to the successful operation of the supply chain because Mo-99 and Tc-99m have short half-lives (approximately 66 hours and 6 hours, respectively) and, therefore, cannot be stockpiled. Furthermore, the activity of Mo-99 declines by about 1 percent per hour because of radioactive decay; thus, it must be moved through the supply chain quickly to minimize decay losses (NAS, 2016).

Demand for Mo-99 is driven by the demand for Tc-99m for medical imaging procedures. The Organization for Economic Cooperation and Development – Nuclear Energy Agency (OECD – NEA), which provides periodic assessments of the global demand for Mo-99 and Tc-99m, reported a global Mo-99 demand in the range of 9500 six-day Ci/week in 2019, with some demand fluctuations seen at a quarterly level (NEA, 2019). OECD – NEA projections are based

on the assumptions that Tc-99m utilization in mature markets will continue to grow at a rate of approximately 0.5 percent annually, and that Tc-99m utilization in emerging markets will increase at an annual rate of 5 percent (NEA, 2019). OECD – NEA projected demand increase in mature markets is generally driven by population aging, while demand growth in emerging markets results from population aging, economic growth, and expansion of the healthcare sector in these countries. Mature markets account for approximately 81.5 percent of global demand, and the United States has historically accounted for about half of the global demand for Mo-99/Tc-99m, while emerging markets account for approximately 18.5 percent of the global demand. Therefore, at least over the next several years, Mo-99/Tc-99m utilization in the United States will drive global demand.

The United States is the largest consumer of Tc-99m, accounting for approximately 50 percent of all procedures that utilize Tc-99m worldwide, which equates to a Mo-99 demand of approximately 4500 six-day Ci/week based on a global demand of 9500 six-day Ci/week. However, until 2018, there had been no domestic (i.e., U.S.-based) production of Mo-99 since the late 1980s; thus, 100 percent of the U.S. supply of Mo-99 was imported (Heltemes, 2020). As noted above, NorthStar began domestic production of Mo-99 via neutron capture technology in 2018. Based on information published by the NEA HLG-MR, NorthStar was projected to have the capacity to process approximately 750 six-day Ci of Mo-99 per week by 2024. However, NorthStar failed to sufficiently penetrate the U.S. market with their combined proprietary produced Mo-99/Tc-99m Generator, RadioGenix, which ceased production in October 2023. Thus, the United States continues to rely on Mo-99 imported from Australia, Europe, and South Africa.

Except for the OPAL reactor in Australia, four of the remaining primary suppliers of fission-produced Mo-99 (HFR, SAFARI-1, BR-2, and LVR-15) use reactors that are over 50 years old, and one supplier (Maria, Poland) uses a reactor that is over 40 years old. The age of these irradiation service supplier reactors increases the potential for unplanned reactor outages and extended outages for major repairs. Unplanned or extended outages of Mo-99 suppliers could reduce available supply capacity below current global demand.

19.1.1.4 Mo-99 from LEU

Mo-99 is produced mostly by fission of U-235 targets in nuclear research reactors. The targets are then processed to separate the Mo-99 and to recover other radioisotopes. OPAL, SAFARI-1, and other reactors, such as Maria, use LEU targets, which adds about 20 percent to production costs. Mo-99 can also be made by bombarding Mo-98 with neutrons in a reactor. However, Mo-99 with this activation has relatively low specific activity.

In December 2012, the U.S. Congress passed the American Medical Isotope Production Act of 2012 to establish a technology-neutral program to support the production of Mo-99 for medical uses in the United States by non-federal entities. Another aspect of this legislation is a proposal for all Mo-99 to be supplied by reactors running on LEU, instead of HEU. As described in Subsection 19.1.1.3, apart from NorthStar, almost all Mo-99 supplied to the United States is from producers located in Australia, Europe, or South Africa. The EIPC manufactures and utilizes LEU targets and contributes to the furtherance of the U.S. nonproliferation goals.

19.1.1.5 Conclusions

Several actions have been taken to improve the resilience of the Mo-99 supply chain. These include the development of outage reserve capacities at several levels within the Mo-99/Tc-99m

supply chain, coordination of reactor and processing facility outages, enhanced communications among supply chain participants, and creation of Mo-99 supplier alliances. Nevertheless, even with the implementation of these supply chain initiatives, vulnerabilities remain within the Mo-99 supply chain primarily relating to the small number of participating organizations. This is particularly true for the front end of the supply chain, where one company (CERCA, France) provides the majority of the targets used for fission-produced Mo-99, and the increased demand for U-235 as reactors convert from HEU to LEU. The relatively small number of global Mo-99 suppliers and the age of the Mo-99 reactors also represent potential vulnerability within the Mo-99 supply chain. There is also potential future vulnerability for Lu-177 target irradiation, as most current reactors that irradiate Mo-99 targets are the same reactors that also irradiate Lu-177 targets. As these reactors potentially become decommissioned within the next decade, the new production capacity created by EIPC benefits patients around the world.

The precarious nature of the global Mo-99 supply chain, national security concerns related to the shipment of HEU and Mo-99, and the U.S. government's continuing support for the domestic production of non-HEU Mo-99 production technologies clearly support the need for a diverse and reliable domestic supply of Mo-99 to support the U.S. healthcare system. This conclusion is supported by the following findings:

- Current global demand for Mo-99, estimated at approximately 9500 six-day Ci/week, is expected to continue to grow with increasing population and increased access to advanced medical services. Even small percentage increases each year could result in periods of shortage, both domestically and globally.
- The short half-lives of Mo-99 (approximately 66 hours) and Tc-99m (approximately 6 hours) prevent ideal inventory levels from being maintained; thus, domestic production capabilities continue to be an important aspect of the U.S. Mo-99 supply chain, as any significant disruption in air transportation of Mo-99 would likely result in significant domestic supply shortages.
- Although NorthStar began production of Mo-99 in 2018, they ceased production in 2023. There is currently no U.S. producer for Mo-99.
- With the exception of the OPAL reactor in Australia, four of the remaining fission-produced Mo-99 suppliers use reactors that are over 50 years old (HFR, SAFARI-1, BR-2, and LVR-15), and one supplier (Maria, Poland) uses a reactor that is over 40 years old. Given the age of these irradiation service supplier reactors, the potential for unplanned reactor maintenance outages continues to present a vulnerability in the Mo-99 supply chain.
- Consistent with the American Medical Isotopes Production Act of 2012, the EIPC utilizes LEU to produce Mo-99, further advancing the U.S. government's nonproliferation goals.

Eden has licensed Sandia National Laboratories' design for a dedicated Mo-99 production open-pool reactor. The EIPC would be capable of meeting the U.S. need for Mo-99 (i.e., approximately 4500 six-day Ci/week). The EIPC would be an important step toward stabilizing the global and U.S. supply of Mo-99/Tc-99m and other medical radioisotopes for the United States and global healthcare systems.

19.1.2 REGULATORY PROVISIONS, PERMITS, AND CONSULTATIONS

In addition to the NRC licensing requirements, construction and operation of the EIPC is subject to a variety of other federal, state, and local environmental regulatory and permitting

requirements. This section summarizes the environmental statutory requirements, regulations, and ordinances relevant to the construction and operation of the EIPC. In addition, as described in the ISG Augmenting NUREG-1537, Chapter 19, and 10 CFR 51.45(d), this section summarizes the status of all applicable federal, state, and local permits and consultations required for construction and operation of the EIPC. Table 19.1.2-1 lists the permits and other approvals required for construction and operation of the EIPC and includes the following information for each permit or approval, as applicable:

- Name of responsible agency.
- Applicable law, ordinance, or regulation.
- Name of permit or approval.
- Activity covered by the permit or approval.
- Current status of each permit or approval.

Table 19.1.2-2 lists the consultations required to support permitting activities for the construction and operation of the EIPC. Table 19.1.2-2 provides the following information for each consultation, as applicable:

- Name of consulting agency.
- Applicable law, ordinance, or regulation.
- Description of the required consultation.
- Summary of surveys required to complete the consultation.
- Current status of each consultation.

In addition to the federal and state permitting requirements listed in Table 19.1.2-1, Lea County, NM, requires permits for most major construction activities. However, these permits are issued in accordance with subdivision ordinances at the time parcel subdivision is approved (Lea County Subdivision Regulations, Ordinance No. 35, Adopted May 20, 1997). Other parcels where subdivision is not requested are not restricted by local subdivision ordinances and do not require county permits for construction activities. As such, building permits for foundations, structures, electrical and mechanical systems, roadways, or temporary construction-related structures are not required by local ordinance, except where subdivision regulations apply. Because subdivision is not necessary for the EIPC, Article 8 of the Lea County, NM, subdivision regulations (or other local regulations) do not apply.

As listed in Table 19.1.2-1, building permits for foundations, structures, and electrical and mechanical systems are required from the New Mexico Regulation and Licensing/Construction Industries Division (NMRLD/CID). These permits are required for temporary construction-related structures (e.g., office trailers), as well as for all permanent structures. Contractors for construction-related activities require a New Mexico license from NMRLD/CID. Site security fencing also requires a permit from NMRLD/CID. There are no known local or county zoning issues that should preclude use of the EIPC site for its stated purpose. Various codes and standards are used for the plant design basis engineering, including those required by federal, state, and local agencies.

In addition to the formal consultations listed in Table 19.1.2-2, Eden has made, or will make, informal contacts with the National Nuclear Security Administration, the Bureau of Indian Affairs,

the New Mexico Department of Health Services, the City of Eunice, NM, and the Economic Development Corporation of Lea County, NM. The purpose of these informal contacts is to inform various government agencies about the EIPC project and to coordinate project planning.

At present, no jurisdictional delays or other problems are identified that would prevent any required agency consultations or approvals. The EIPC is designed and planned to comply with all applicable environmental quality standards and regulatory requirements. Additionally, the EIPC complies with current FDA and International Organization for Standardization “good manufacturing practices,” as followed by the pharmaceutical industry at large.

Table 19.1.2-1
(Sheet 1 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
NRC	Atomic Energy Act of 1954, as amended (42 U.S.C. § 2011 et seq.)			
	10 CFR 50.50	Construction Permit (CP)	Construction of the EIPC	Permitting process initiated with this license application.
	10 CFR 50.57	Operating License (OL)	Operation of the EIPC, excluding target fabrication	Application for the OL will be submitted subsequent to submittal of the CP application.
	10 CFR Part 30	Radioactive Byproduct Material License	Production, possession, and transfer of radioactive byproduct material	Application for this license will be submitted subsequent to submittal of the CP application.
	10 CFR Part 70	Special Nuclear Material (SNM) License	Receipt, possession, use, and transfer of SNM	The SNM license application will be submitted subsequent to submittal of the CP application.
	10 CFR Part 71	General License	Packaging and transportation of radioactive material	The general license application will be submitted subsequent to submittal of the CP application.
	NEPA of 1969, as amended (42 U.S.C. § 4321 et seq.) 10 CFR Part 51	Environmental Assessment (EA) or Environmental Impact Statement (EIS) as required by NRC NEPA implementing regulations at 10 CFR Part 51	Environmental impacts resulting from the construction, operation, and decommissioning of a medical radioisotope production facility	NEPA requirements for the construction of the EIPC are addressed in this license application. A supplement to the ER will be submitted with an application for an OL and a license to receive, possess, and use SNM.

Table 19.1.2-1
(Sheet 2 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
Federal Aviation Administration (FAA)	Federal Aviation Act of 1958, as amended (49 U.S.C. §1031 et seq.) 14 CFR Part 77	Construction Notice	Construction of structures greater than 200 feet above ground level and other structures the construction of which could impact air navigation	Notification has not yet been submitted. Eden expects to submit an evaluation request to the FAA at least 45 days prior to the start of construction.
U.S. Environmental Protection Agency (USEPA)	Resource Conservation and Recovery Act, as amended (42 U.S.C. §6901 et seq.) 40 CFR Part 261 and Part 262	USEPA acknowledgement of notification of hazardous waste activity	Generation of hazardous wastes as defined in 40 CFR Part 261	Notification has not yet been submitted. Eden expects to submit the notification of hazardous waste activity prior to commencing any project-related activities that result in the generation of hazardous wastes.
	Clean Water Act of 1972, as amended (33 U.S.C. §1251 et seq.) 40 CFR Part 112, Appendix F	Spill Prevention, Control and Countermeasure (SPCC) Plans for Construction and Operation	Storage of oil and other petroleum products during construction and operation	SPCC Plans have not yet been prepared. Eden will prepare the SPCC Plan for construction activities prior to the construction start date, and the SPCC Plan for operation prior to commencing operation of the EIPC.
	40 CFR Part 122	National Pollutant Discharge Elimination System (NPDES) Construction General Stormwater Permit	Discharge of stormwater runoff associated with construction activities that disturb 1 acre or more of land	USEPA is the regulatory authority for the stormwater permitting program in New Mexico. Eden will submit the required Notice of Intent (NOI) and Stormwater Pollution Prevention Plan (SWPPP) approximately 30 days prior to the commencement of construction activities.

Table 19.1.2-1
(Sheet 3 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
USEPA (continued))	40 CFR Part 122	Industrial Facility Stormwater Discharge Permit	Discharge of stormwater runoff from industrial facilities during operation	USEPA is the regulatory authority for the stormwater permitting program in New Mexico. Eden will submit the required NOI approximately 30 days prior to the commencement of facility operations.
	Clean Air Act of 1972, as amended (42 U.S.C. §7401 et seq.) 40 CFR Part 51 40 CFR Part 71	New Source Review Air Permit, including minor source review; and Part 71 Federal Operating Permit	Construction and Operating Permits for new stationary sources of emissions	The New Mexico Environment Department (NMED) is authorized to implement Clean Air Act permitting requirements in New Mexico; therefore, the air permit application will be submitted to NMED and all required air permits will be issued by NMED.
	Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 (42 U.S.C. §11001 et seq.) (also known as Superfund Amendments and Reauthorization Act (SARA) Title III) 40 CFR Part 355, Part 370, and Part 372	Requires EIPC to report on hazardous and toxic chemicals used and produced at the facility, and to establish emergency planning procedures in coordination with local communities and state agencies	Presence, storage, use, or release of specific hazardous substances listed in 40 CFR 302.4	Eden will initiate coordination with local and state agencies, as required, prior to storing or using listed hazardous substances. Submittal will be coordinated with the New Mexico Department of Homeland Security and Emergency Management.

Table 19.1.2-1
(Sheet 4 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
U.S. Department of Transportation Federal Motor Carrier Safety Administration (FMCSA)	Hazardous Materials Transportation Act of 1975 (49 U.S.C. §1801 et seq.) 49 CFR Part 107, 49 CFR Part 171, 49 CFR Part 172, 49 CFR Part 173, Subpart I “Radioactive Materials”	Certificate of Registration	Transportation of hazardous materials including radioactive materials	Registration has not yet been submitted. Eden expects to submit the registration material approximately 90 days prior to offering hazardous or radioactive materials for transport.
New Mexico Environment Department (NMED) *NMED Air Quality Bureau*	New Mexico Air Quality Control Act New Mexico Statutes Annotated (NMSA), Chapter 74 “Environmental Improvement” Article 2 “Air Pollution” New Mexico Administrative Code (NMAC), Title 20 “Environmental Protection” Chapter 2 “Air Quality”	NMAC Title 20, Part 72 Construction Permit and Part 70 Operating Permit Requires a permit prior to construction of a stationary source of emission. Also requires an operating permit for major emission sources and imposes emission standards for hazardous air pollutants.	Construction and operation of a new stationary source of emissions	The construction permit application has not yet been submitted. Eden anticipates submitting the construction permit application approximately 180 days prior to the construction start date. The operating permit application, if appliable, will be submitted following construction of the facility.
NMED Surface Water Quality Bureau	New Mexico Water Quality Act NMSA Chapter 74 “Environmental Improvement” Article 6 “Water Quality” NMAC Title 20 “Environmental Protection” Chapter 6 “Water Quality”	Requires compliance with state water quality standards, including a permit for the discharge of pollutants to waters of the state	Discharge of pollutants to waters of the state	Discharge permit application has not yet been submitted. Eden anticipates submitting the discharge permit application approximately 180 days prior to the construction start date, if applicable.

Table 19.1.2-1
(Sheet 5 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
NMED Groundwater Quality Bureau	NMAC Title 20 "Environmental Protection" Chapter 6 "Water Quality" Part 2 "Ground and Surface Water Protection"	Ground Water Discharge Permit	Discharge of industrial or domestic wastewater to a lined lagoon or holding tank	Eden anticipates submitting a Discharge Permit Application for the evaporation pond at least six months prior to construction.
NMED Groundwater Quality Bureau	New Mexico Groundwater Protection Act NMSA Chapter 74 "Environmental Improvement" Article 6B "Groundwater Protection" NMAC Title 20 "Environmental Protection" Chapter 5 "Petroleum Storage Tanks"	Requires compliance with state standards protecting groundwater from leaking underground and aboveground storage tanks, including requirements for a Groundwater Protection Permit for certain activities	Discharge of industrial or domestic wastewater to a lined lagoon or holding tank	Eden anticipates submitting an NOI to allow NMED to determine whether a groundwater Discharge Permit is needed for any activity at the EIPC, if applicable.
NMED Solid Waste Bureau	New Mexico Solid Waste Act NMSA Chapter 74 "Environmental Improvement" Article 9 "Solid Waste Act" NMAC Title 20 "Environmental Protection" Chapter 9 "Solid Waste"	Establishes state standards for the management and disposal of solid wastes	Management and disposal of solid wastes	Solid wastes generated at the EIPC will be disposed of at an appropriately permitted solid waste disposal facility.
NMED Hazardous Waste Bureau	New Mexico Hazardous Waste Act NMSA Chapter 74 "Environmental Improvement" Article 4 "Hazardous Wastes" NMAC Title 20 "Environmental Protection" Chapter 4 "Hazardous Waste"	Requires compliance with state standards regarding the management of hazardous waste, including notification of hazardous waste activities	Generation, storage, treatment, and disposal of hazardous waste as defined in NMSA 74-4-3	Notification not yet submitted. Eden expects to submit the notification of hazardous waste activity prior to commencing any project-related activities that result in the generation of hazardous wastes.

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Table 19.1.2-1
(Sheet 6 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
NMED Petroleum Storage Tank Bureau (PSTB)	Aboveground Storage Tank Registration Hazardous Waste Act, Sections 74-4-1 through 74-4-14 NMSA 1978; Ground Water Protection Act, Sections 74-6B-1 through 74-6B-14 NMSA 1978; and general provisions of the Environmental Improvement Act, Sections 74-1-1 through 74-1-17 NMSA 1978. NMAC Title 20 “Environmental Protection” Chapter 5 “Petroleum Storage Tanks”	Petroleum storage tank registrations and permits	Installation of petroleum storage tanks	Registration has not yet been submitted. Eden expects to submit the registration forms, if required, approximately 60 days prior to tank installation.
New Mexico Department of Homeland Security and Emergency Management (DHSEM)	New Mexico Hazardous Chemicals Information Act NMSA Chapter 74 “Environmental Improvement” Section 4E “Hazardous Chemicals Information Act”	Implements the hazardous chemicals information and toxic release reporting requirements of EPCRA. EPCRA is administered by the USEPA and is implemented by the New Mexico DHSEM	Presence, storage, use, or release of specific hazardous substances as defined in Title 3 of the federal Emergency Planning and Community Right-to-Know Act of 1986	Eden will initiate coordination with DHSEM prior to storing or using listed hazardous substances.
NMED Radiation Control Bureau	New Mexico Radioactive and Hazardous Material Act (20.3 NMAC) NMSA Chapter 74 “Environmental Improvement” Article 4A “Radioactive Materials” NMAC Title 20 “Environmental Protection” Chapter 3 “Radiation Protection”	Regulates radioactive materials in accordance with the requirements of the New Mexico Radiation Protection Regulations	Applies to all persons who receive, possess, use, transfer, own or acquire any source of radiation; provided that, regulations at 20.3 NMAC do not apply to any person to the extent that such person is subject to regulations by the NRC	Construction and operation of the EIPC are subject to regulation by NRC; therefore, Eden is not subject to the provisions of 20.3 NMAC.

Table 19.1.2-1
(Sheet 7 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
New Mexico Department of Game and Fish (NMDGF)	New Mexico Wildlife Conservation Act NMSA Chapter 17 "Game and Fish and Outdoor Recreation" Article 2 "Hunting and Fishing Regulations" Part 3 "Wildlife Conservation Act" Section 17-2-14 "Hawks, vultures and owls: taking, possessing, trapping, destroying, maiming, or selling prohibited; except by permit; penalty" NMAC Title 19 "Natural Resources and Wildlife" Chapter 33, "Endangered and Protected Species"	Requires permit and coordination if a project may disturb habitat or otherwise affect threatened or endangered species, and makes it unlawful to take, attempt to take, possess, trap, ensnare, injure, maim, or destroy any species of hawks, owls, and vultures	Applies to activities that remove, capture, or destroy an endangered species or disturb species habitat, and activities that result in the taking, injuring, maiming, or destruction of raptor species	At this time there are no known threatened or endangered species on the EIPC site, and the project is not expected to adversely affect hawks, owls, or vultures. Eden will consult with NMDGF prior to commencing construction activities.
State of New Mexico Energy, Minerals, and Natural Resources Department – Forestry Division	*New Mexico Rare and Endangered Plants Program* NMSA Chapter 75, "Miscellaneous Natural Resource Matters" Article 6, "Endangered Plants" NMAC Title 19 "Natural Resources and Wildlife" Chapter 21 "Endangered Plants"	Requires the agency to establish an endangered plant species list and rules for collection, and requires coordination with the state if a proposed project affects an endangered plant species	Construction activities affecting endangered plant species	At this time, there are no known endangered plant species on the EIPC site.

Table 19.1.2-1
(Sheet 8 of 8)
Permits and Approvals Required for Construction and Operation

Agency	Regulatory Authority	Permit or Approval	Activity Covered	Status
New Mexico Department of Transportation	Transportation and Highway NMSA Chapter 67 “Highways” NMAC Title 18 “Transportation and Highways” Chapter 31 “Classification and Design Standards for Highways” Part 6 “State Highway Access Management Requirements”	Highway Access Management Permit (18.31.6.14 NMAC)	Permit for NM-176 driveway entry and second (emergency) access point, if applicable	The highway access permit application has not yet been submitted. Eden anticipates submitting the permit application approximately 90 days prior to the construction start date.
New Mexico Regulation and Licensing Department – Construction Industries Division (NMRLD/CID)	Housing and Construction NMSA Chapter 60 “Business Licenses” Article 13 “Construction Industries Licensing” NMAC Title 14 “Housing and Construction” Chapter 5 “Construction Industries General Provisions.	Building permits required for temporary construction-related structures (e.g., office trailers), as well as all permanent structures. Contractors for construction-related activities will require a New Mexico license from NMRLD/CID.	Construction of foundations, structures, and electrical and mechanical systems	Building permit applications have not yet been submitted. Eden anticipates submitting applicable applications approximately 90 days prior to the construction start date.

Abbreviations: NRC = U.S. Nuclear Regulatory Commission | U.S.C. = United States Code | CFR = Code of Federal Regulations | EIPC = Eden Isotope Production Complex | NEPA = National Environmental Policy Act | ER = Environmental Report | NM = New Mexico

Table 19.1.2-2
(Sheet 1 of 3)
Consultations Required for Construction and Operation

Agency	Regulatory Authority	Description of Required Consultation	Surveys Required to Complete Consultation	Status
U.S. Fish and Wildlife Service (USFWS) and U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, as appropriate	Endangered Species Act of 1973, as amended (16 U.S.C. §1531 et seq.)	Consultation to identify potential adverse impacts to federally protected species and critical habitat, and concurrence from USFWS of no adverse impact or consultation with the agency to identify and implement appropriate mitigation measures. Consultation with NOAA is not required for the proposed project.	No field surveys are anticipated	By letter dated September 30, 2022, Eden initiated the consultation process with the USFWS. The USFWS responded by email dated November 29, 2022. Consultation documents are provided in Appendix 19A of this ER.
USFWS	Bald and Golden Eagle Protection Act, 16 U.S.C. 668-668c	Consultation regarding potential adverse impacts to eagles, and concurrence from USFWS of no adverse impacts or consultation with the agency to identify and implement appropriate mitigation measures	No field surveys are anticipated	By letter dated September 30, 2022, Eden initiated the consultation process with the USFWS. Consultation regarding bald and golden eagles was coordinated with the Endangered Species Act consultation process. The USFWS responded by email dated November 29, 2022. Consultation documents are provided in Appendix 19A of this ER.

Table 19.1.2-2
(Sheet 2 of 3)
Consultations Required for Construction and Operation

Agency	Regulatory Authority	Description of Required Consultation	Surveys Required to Complete Consultation	Status
New Mexico Department of Game and Fish (NMDGF)	New Mexico Wildlife Conservation Act New Mexico Statutes Annotated, Chapter 17, "Game and Fish and Outdoor Recreation," Article 2, "Hunting and Fishing Regulations," Part 3, "Wildlife Conservation Act"	Consultation regarding potential adverse impacts to state-protected species and protected habitat, and concurrence from NMDGF of no adverse impacts or consultation with the agency to identify and implement appropriate mitigation strategies	No field surveys are anticipated	By letter dated September 30, 2022, Eden initiated the consultation process with the NMDGF. The NMDGF responded by email dated February 21, 2023. Consultation documents are provided in Appendix 19A of this ER.
New Mexico Department of Cultural Affairs – New Mexico Historic Preservation Division	New Mexico Cultural Properties Protection Act New Mexico Statutes Annotated (NMSA), Chapter 18, "Libraries Museums and Cultural Properties," Article 6, "Cultural Properties" New Mexico Administrative Code, Title 4 "Cultural Resources," Chapter 10 "Cultural Properties and Historic Preservation"	Consultation regarding potential adverse impacts to historic and cultural resources, and concurrence from the Historic Preservation Division of no adverse impacts or consultation with the agency to identify and implement appropriate mitigation strategies	A Phase I cultural resource survey of the proposed EIPC site conducted in April 2020 did not identify any significant historic or cultural resources at the site (ER Section 19.4.6). No additional field surveys are anticipated.	By letter dated September 30, 2022, Eden initiated the consultation process with the New Mexico Department of Cultural Affairs – Historic Preservation Division. The Historic Preservation Division responded by letter dated October 14, 2022. Consultation documents are provided in Appendix 19A of this ER.
Texas Parks and Wildlife Department (TPWD)	Title 31 of the Texas Administrative Code Part 2, Texas Parks and Wildlife Department, Chapter 65, "Wildlife," and Chapter 69, "Resource Protection"	Consultation regarding potential adverse impacts to state-protected species and protected habitat, and concurrence from TPWD of no adverse impacts or consultation with the agency to identify and implement appropriate mitigation strategies	No field surveys are anticipated	By letter dated December 15, 2022, Eden initiated the consultation process with TPWD. The TPWD responded by email dated January, 2023. Consultation documents are provided in Appendix 19A of this ER.

Table 19.1.2-2
(Sheet 3 of 3)
Consultations Required for Construction and Operation

Agency	Regulatory Authority	Description of Required Consultation	Surveys Required to Complete Consultation	Status
Apache Tribe of Oklahoma; Comanche Nation of Oklahoma; Kiowa Tribe; Mescalero Apache Tribe; Ysleta del Sur Pueblo; Lipan Apache Tribe of Texas; Texas Band of Yaqui Indians; Tonkawa Tribe of Oklahoma; Wichita and Affiliated Tribes	National Environmental Policy Act (NEPA) National Historic Preservation Act (NHPA) The Native American Graves Protection and Repatriation Act (Public Law 101-601; 25 U.S.C. 3001-3013) 36 CFR Part 79 Curation of Federally-Owned and Administered Archaeological Collections	Consultation regarding protection of traditional Native American religious and cultural resources	A Phase I cultural resource survey of the proposed EIPC site conducted in April 2020 did not identify any significant historic or cultural resources at the site (ER Section 19.4.6). No additional field surveys are anticipated.	By letters dated September 30, 2022, Eden initiated the consultation process with the affected Native American Tribes. Tribal responses and consultation documents are provided in Appendix 19A of this ER.

Abbreviations: U.S.C. = United States Code | ER = Environmental Report

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Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 19
Environmental Report

Section 19.2
Proposed Action

eden | Precision Science. Human Impact.

CHAPTER 19
ENVIRONMENTAL REPORT

SECTION 19.2 PROPOSED ACTION

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°F	degree(s) Fahrenheit
ABO	alpha benzoin oxime
ACC	Access Control Center
ac.	acre(s)
$AgNO_3$	silver nitrate
AHA	acetohydroxamic acid
AIP	Activation Isotope Processing
Al	aluminum
ALARA	As Low As Reasonably Achievable
AOC	Administration Office Complex
Be	beryllium
Ca	calcium
CAM	continuous-air monitor
CFR	Code of Federal Regulations
ClO_2	chlorine dioxide
cm	centimeter(s)
CP	construction permit
CQA	construction quality assurance
DECON	decommissioning decontamination option
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex

Acronym/Abbreviation	Definition
EMIF	Eden Medical Isotope Facility
ER	Environmental Report
ft.	foot/feet
ft^3	cubic foot/feet
(g)	gaseous
g	gram(s)
gal.	gallon(s)
gpm	gallon(s) per minute
H	hydrogen
H_2O_2	hydrogen peroxide
H_2SO_4	sulfuric acid
ha	hectare(s)
HCF	Hot Cell Facility
HCl	hydrochloric acid
HEGA	high-efficiency gas absorber
HEPA	high-efficiency particulate air (filter)
HNO_3	nitric acid
HVAC	heating, ventilation, and air-conditioning
I-131	iodine-131
I-20	Interstate 20
K_3RuCl_6	potassium hexachlororuthenate
$KMnO_4$	potassium permanganate
kg	kilogram(s)
km	kilometer(s)
L	liter(s)

Acronym/Abbreviation	Definition
lb.	pound(s)
LECS	liquid effluent control system
LEU	low-enriched uranium
LIP	Local Intense Precipitation
LLW	low-level (radioactive) waste
LN2	liquid nitrogen
lpm	liters per minute
Lu-177	lutetium-177
M	molarity
m	meter(s)
m^3	cubic meter(s)
MDCT	mechanical-draft cooling tower
MGPY	million gallon(s) per year
mi.	mile(s)
MLPY	million liter(s) per year
Mo-99	molybdenum-99
MWt	megawatt(s) thermal
N_2	nitrogen
NaI	sodium iodide
NaClO	sodium hypochlorite
NaOH	sodium hydroxide
Ni	nickel
NM	New Mexico
NM-18	New Mexico Highway 18
NM-176	New Mexico Highway 176

Acronym/Abbreviation	Definition
NMDOT	New Mexico Department of Transportation
NRC	U.S. Nuclear Regulatory Commission
O_2	oxygen
OCA	owner-controlled area
OH	hydroxide
OL	operating license
oz.	ounce(s)
POC	Production Office Complex
PPE	personal protective equipment
PWH	Production Warehouse
QC	quality control
RCRA	Resource Conservation and Recovery Act
RF	Reactor Facility
$RhCl_3H6O_3$	rhodium chloride trihydrate
(s)	solid
SCB	steel confinement box
SNM	special nuclear material
T	ton(s)
TBP	tributyl phosphate
TiO_2	titanium dioxide
TN	Tennessee
TX	Texas
U	uranium
U-235	uranium-235
U_3O_8	uranium oxide

Acronym/Abbreviation	Definition
URENCO	Urenco USA
U.S.	United States
UREX	uranium extraction
VOC	volatile organic compound(s)
WCS	Waste Control Specialists, LLC
Xe-133	xenon-133
yd^3	cubic yard(s)

19 Environmental Report

19.2 PROPOSED ACTION

19.2.1 PROPOSED ACTION SUMMARY

Eden Radioisotopes, LLC (Eden) proposes to construct and operate an isotope production complex near Eunice, New Mexico (NM), for the purpose of providing to the United States a supply of certain radioisotopes for use in the medical community (see Figure 19.2.1-1 and Figure 19.2.1-2).

The Eden Isotope Production Complex (EIPC) consists of the following buildings: the Administration Office Complex (AOC), Access Control Center (ACC), Production Office Complex (POC), Production Warehouse (PWH), and Eden Medical Isotope Facility (EMIF). Within the EMIF, there is a Reactor Facility (RF) and a Hot Cell Facility (HCF). The RF contains a steady-state non-power reactor used to irradiate targets. It includes the RF high bay, reactor pool, and reactor control room. The HCF is a facility used to separate desired radioisotopes from irradiated targets and it includes the HCF target processing high bay, target fabrication area, activation isotope processing (AIP) area, HCF target processing canyon, and waste storage canyon. The proposed federal action is issuance of a construction permit (CP) under Title 10 of the Code of Federal Regulations (10 CFR), Part 50, Domestic Licensing of Production and Utilization Facilities, to Eden for construction of a 10 CFR Part 50 utilization facility and a 10 CFR Part 50 production facility. The EIPC produces molybdenum-99 (Mo-99), iodine-131 (I-131), and xenon-133 (Xe-133) through the fission process and other isotopes — such as lutetium-177 (Lu-177) — through neutron activation (NASEM, 2016). The decay product of Mo-99, technetium-99m, is used for diagnostic medical procedures.

Eden is also considering either: (1) fabricating low-enriched uranium (LEU) targets at the EIPC; (2) acquiring the targets from an outside vendor; or (3) both. Both on-site fabricating and acquiring targets from an outside vendor are discussed in this Environmental Report (ER). At the operating license stage, Eden will apply for the issuance of a license under 10 CFR Part 70, Domestic Licensing of Special Nuclear Material, to receive, possess, and use special nuclear material (SNM) for the production of targets. The issuance of the CP is a separate licensing action from the application and issuance of an operating license (OL) under 10 CFR Part 50 for the utilization and production facilities and the 10 CFR Part 70 SNM license for target fabrication. A supplement to this ER is to be submitted with the application for a 10 CFR Part 50 OL and a 10 CFR Part 70 license to receive, possess, and use SNM for target production; however, operation and decommissioning of the EIPC — and construction, operation, and decommissioning of the target fabrication area if target fabrication occurs at the EIPC — are connected actions to issuance of this CP and are addressed in this ER.

Upon the United States (U.S.) Nuclear Regulatory Commission (NRC) issuing a CP, OL, and SNM license to Eden, Eden would be authorized to:

- Construct, operate, and decommission (with approval of a decommissioning plan) the EMIF (RF and HCF, including the target fabrication area if part of the EMIF).
- Receive fresh LEU or LEU targets from the U.S. Department of Energy (DOE) and/or various commercial uranium (U) fabrication facilities.
- Process LEU targets to extract medical isotope products and reclaim the LEU.

- Fabricate new targets from the reclaimed LEU (if Eden decides to fabricate on-site).
- Manage, package, and ship marketable radionuclide products to end users.
- Manage, package, and ship radioactive waste for disposal.
- Manage, package, and ship reclaimed LEU to the DOE and/or various commercial U fabrication facilities.

The applicant for the CP, OL, and SNM license, and the owner of the EIPC, is Eden Radioisotopes, LLC, a New Mexico-based company. When the CP, OL, and SNM license are approved, Eden has the necessary authority, control, and rights related to the construction and operation of the EIPC.

The area surrounding the EIPC project site consists of undeveloped brushland and industrial properties (see Figure 19.2.1-1). The EIPC project site consists of 240 acres (ac.) (97 hectares [ha]) in the northeast quarter of Section 6 (640 ac. [259 ha]) within Township 22S, Range 38E, along with portions of the northwest, southwest, and southeast quarters (ESRI, 2022; GIS, 2021; USGS, 2019). The site location is 32° 25’ 25.44” N latitude, and 103° 5’ 46.14” W longitude.

The project site is located on relatively flat terrain with a gentle slope of approximately 0.5 – 1.0 percent. Surrounding properties consist of: (1) undeveloped land; (2) the Urenco USA (URENCO) enrichment plant, approximately 1.3 miles (mi.) (2.1 kilometers [km]) to the northeast; (3) the planned C.K. Disposal, LLC, landfill, approximately 1.1 mi. (1.7 km) to the east; and (4) the Lea County, NM, landfill, approximately 1.6 mi. (2.6 km) east of the center of the site (PSC & CC, 2015). The Waste Control Specialists LLC (WCS) low-level waste (LLW) disposal site in Andrews, Texas (TX) is approximately 2.6 mi. (4.2 km) to the east-northeast of the center of the EMIF RF. Land to the south and west of the EIPC project site is owned by Walco Ranch, LLC, and is predominantly undeveloped brushland (Lea County, 1920). The EIPC project site’s northern boundary is bordered by undeveloped land owned by Louisiana Energy Services, LLC (licensed to URENCO) (NRC, 2022). There is a plugged oil well (30-025-22804 PRE-ONGARD WELL #001) approximately 0.5 mi. (0.8 km) northwest of the center of the site (NMOCD, 2021).

The land around the EIPC project site has historically been utilized by the oil and gas industries. Further description of the project site area and the current state of the project site is provided in Section 19.3 of this ER.

As part of the EIPC project, an off-site utility corridor is constructed for the site’s potable water supply, as well as for sanitary water discharge. The utility corridor runs along New Mexico Highway 176 (NM-176) to the west, toward Eunice, NM, for approximately 1.6 mi. (2.6 km). See Figure 19.2.1-3 for details regarding the off-site utility corridor.

19.2.1.1 Description of Proposed / Connected Actions

The EIPC project includes project site preparation, including: (1) grading and utilities; (2) the construction of buildings, including the AOC, ACC, POC, PWH, and EMIF; (3) the construction of off-site potable water supply and sanitary waste discharge pipelines; and (4) the construction of other site spaces and features, such as the cooling towers, electrical substation, parking area, access roads, stormwater runoff pond, evaporation pond, and drainage channels.

A map including the off-site utility corridor is shown in Figure 19.2.1-3, and the schematic layout of the EIPC is shown in Figure 19.2.1-4.

The EIPC is constructed on a 240-ac. (97-ha) project site (245.6-ac. [99-ha] including easement) near NM-176, east of Eunice, NM (see Figure 19.2.1-4).

19.2.1.2 Project Phases

The various phases of the EIPC project are:

a. Construction activities not requiring authorization by the CP.
b. CP-authorized construction.
c. Preoperational activities authorized by the CP.
d. Operation.
e. Decommissioning.

19.2.1.2.1 Construction Activities Not Requiring Authorization by the Construction Permit

Construction involves certain tasks for which NRC approval, in accordance with 10 CFR 50.10, is not required, such as preparatory activities. Activities preparatory in nature do not involve any NRC-regulated processes or safety-related equipment or systems. A spill prevention, control, and countermeasures plan and a National Pollutant Discharge Elimination System construction stormwater permit, along with state and local permits, need to be issued prior to the implementation of construction activities (USEPA, 2019). These preparatory construction activities affect only the timing of work and do not increase the scope or environmental impact of overall facility construction. Potential preparatory construction activities include:

- Clearing land.
- Installing a water supply line.
- Installing a waste discharge line.
- Site grading and erosion control.
- Excavating activities for the EMIF basement and reactor pool.
- Bulk material transport and concrete batch plant.
- Installing main entrance roadbed.
- Installing drainage ditches and stormwater retention pond to manage the site runoff.
- Installing evaporation pond.
- Installing construction trailer(s).
- Preparing preliminary site roadways and a gravel parking area.
- Constructing the electrical power substation.
- Constructing the POC.
- Constructing the AOC.
- Constructing the ACC.

- Constructing the PWH.
- Installing temporary fencing.
- Installing a firewater pump house with a firewater tank.
- Installing a truck washing station.
- Installing New Mexico Department of Transportation (NMDOT) required acceleration/deceleration lanes on NM-176.
- Obtaining the required local, state, and federal permits.

The project site characteristics are such that major earth grading or movement is not necessary. Retention pond, evaporation pond, swales, drainage ditches, roads, pads, building foundations, and floors require excavation. Estimated excavation for construction is discussed in Subsection 19.4.3.2.1. The EIPC requires the installation of water lines, sewer lines, and electrical utility lines. The need for major earthwork is not anticipated; however, very dense soil (caliche) is expected at 2 – 5 feet (ft.) (0.6 – 1.5 meters [m]) below grade and needs to be removed completely and replaced with granular backfill material.

19.2.1.2.2 Construction Permit-Authorized Construction

A CP is required for activities that are outlined by 10 CFR 50.10. After NRC approval of the CP application, CP-authorized construction begins. Such activities include the following (USEPA, 2019):

- Completing site grading.
- Completing access road(s) and the parking lot.
- Pouring of the EMIF building structure and shield wall footings.
- Pouring of the shield wall, transfer canal, and reactor pool support concrete.
- Installing the reactor pool liner and transfer canal.
- Completing the building structures, including utilities.
- Obtaining the required local, state, and federal permits.
- Installing process equipment and other interior infrastructure.

19.2.1.2.3 Preoperational Activities Under the Construction Permit

Preoperational activities conducted under the CP include:

- Installing and checkout of equipment.
- Conducting cold formal and hands-on staff training.
- RF and HCF cold startup activities.
- Finalizing RF configuration and HCF equipment and processing configurations.
- Completing the OL Application for the EIPC.

- Finalizing operating procedures and technical specifications.
- Conducting a readiness review.

Throughout this ER, where applicable, preoperational activities under the CP are discussed as part of CP-authorized construction.

19.2.1.2.4 Operation

Following receipt of the OL from the NRC, the initial operation of the EIPC involves hot testing and commissioning, staffing of the facility to appropriate levels for market entry-level production, and ramp-up entry-level production. This is followed by the commercial operation of the facility to produce medical radioisotopes.

19.2.1.2.5 Decommissioning

The EIPC is licensed to operate for 40 years. At the end of this period, Eden may file a timely application for license renewal. When operation ends, the EIPC is decontaminated and decommissioned in accordance with applicable NRC license termination requirements. The EIPC is decommissioned such that the site and remaining facilities can be released for unrestricted use as defined in 10 CFR 20.1402, Radiological Criteria for Unrestricted Use. Decommissioning also involves the dismantling of the RF and HCF, including the target fabrication area. Decontamination and decommissioning occurs over the course of two years. Decommissioning employs an average of 44 full-time workers, with up to 71 full-time workers at peak times.

The decommissioning plan will be submitted to the NRC in accordance with 10 CFR 50.82(b)(1), one year prior to the expiration of the OL or within two years following permanent cessation of facility operation, whichever comes first. Decommissioning will be performed using the decontamination (DECON) option to meet the regulatory requirement in 10 CFR 50.82(b)(4)(i) to select an alternative for decommissioning, which provides for the completion of decommissioning without significant delay. SNM will be removed from site and disposed of as radioactive waste or returned to the DOE. Decommissioning of the EIPC will include decontamination or removal of radioactive equipment and other materials that will be shipped off site for licensed disposal. Whether material is ultimately removed from the site depends on whether it is decontaminated down to release-criteria levels; if the release-criteria levels are achieved, then applicable equipment and materials may remain in place. Radioactively contaminated equipment and materials will be sent to an NRC-licensed disposal facility for treatment, disposal, or both.

19.2.1.3 Schedule for Proposed Action

The projected schedule for the EIPC is as follows:

a. Construction activities not requiring authorization by the CP: November 2026.
b. CP-authorized construction: July 2027.
c. Preoperational activities authorized by the CP: April 2030.
d. Beginning of commercial operation: July 2030.
e. Beginning of decommissioning: August 2070.

f. End of decommissioning / license termination: August 2072.

19.2.1.4 Land Usage

19.2.1.4.1 Construction

Conventional earthmoving and grading equipment is used during the construction phase of the EIPC. Caliche encountered during excavation for foundations, utility trenches, and ponds is removed and replaced with suitable backfill material. Additionally, heavy equipment with ripping tools may be required for the removal of caliche. Soil removal for foundations is minimized. In addition, loose soil and damaged caliche are removed prior to installation of foundations for seismically designed structures. Based on the site layout, about 93.2 ac. (37.7 ha), 37.9 percent of the project area, is expected to be disturbed. This includes approximately 37.5 ac. (15.2 ha) of temporarily disturbed areas for construction laydown and parking. Additionally, approximately 33.2 ac. (13.4 ha) is expected to be temporarily disturbed for the off-site utility corridor. Roads are repaired, as required, for installation of utilities.

During the construction phase, a portion of the 245.6-ac. (99-ha) EIPC project area is graded to provide an approximately level grade at an elevation of 3373.5 ft. (1028.2 m) above mean sea level for the EMIF. Other areas of the facility have slightly different elevations to ensure that earthwork is balanced.

The EMIF is located near the center of the property. The area occupied by the EMIF, including buildings, parking spaces, and security buffer areas, is graded to:

- Keep the EMIF above the runoff depth due to a Local Intense Precipitation (LIP) event, and the remainder of the facility above the 100-year runoff depth.
- Provide positive surface drainage to keep the runoff away from EIPC buildings.
- Provide suitable subsurface conditions adequate for basement and building foundations.

Based on the current building/equipment layout and the available site surveys, the total amount of fill required to grade the site to the finish-grade elevations is 180,200 cubic yards (yd^3) (137,800 cubic meters [m^3]), most of which is likely available from on-site excavation. During construction, a few feet (approximately 1 m) in depth of native soil is removed in the areas of buildings, adjacent pads, and utility trenches to provide adequate bearing for concrete floors, foundations, pads, and utility trenches. The backfill material and compaction requirements for components such as foundations and utility trenches are in accordance with the earthwork specifications suitable for the load-bearing requirements. To keep the finish-grade elevation of the site above the high-water elevation generated from a 100-year rainfall event, about 180,200 yd^3 (137,800 m^3) of fill is required. Approximately 132,650 yd^3 (101,420 m^3) of fill material is available from on-site excavation of foundations, and the remaining 47,550 yd^3 (36,350 m^3) of fill is imported from an off-site source. In addition, for the off-site corridor for the potable water pipeline and the wastewater pipeline, the quantity of backfill required is 4996 yd^3 (3820 m^3) and the quantity of waste generated is 5185 yd^3 (3964 m^3).

The amount of earthwork required for roadwork within the project site area depends on the final alignment of the access road to NM-176. Additionally, NMDOT acceleration and deceleration lanes will be added to NM-176 at the entrance to the EIPC. Grading and preparation of a temporary construction access road occur at the beginning of construction activities, and completion of permanent roadways, parking areas, finished grading, and landscaping occurs at

the end of construction activities. Temporarily disturbed areas of the site during construction are restored using native vegetation.

Any excess suitable excavated material is stockpiled at the site at a designated location with adequate erosion control measures installed. Unsuitable excavated material is disposed of at an approved off-site landfill location.

19.2.1.4.2 Operations

Operation of the EIPC does not require land use changes beyond those described for construction activities and does not require the use of any new land; therefore, 55.7 ac. (22.5 ha) of land, 22.7 percent of the project area, is used during operations.

19.2.1.4.3 Decommissioning

Decommissioning activities are substantially similar to construction activities, wherein heavy equipment is used to dismantle buildings to the extent needed for unrestricted release and, if needed, remove roads and parking areas. The land required for decommissioning activities is similar to or less than that needed for construction and is limited to the EIPC project site. After completion of decommissioning, the project site may be returned to range land; alternatively, if structures remain, they could be used for other industrial purposes.

19.2.1.5 Workers

The estimated number of workers (full-time equivalent, which also includes contractors) involved in the various phases of the EIPC project are as follows:

a. Construction: 26 – 233, depending on the phase.
b. Pre-Operations: 79 – 142.
c. Operations: 119 – 146.
d. Decommissioning: up to 71, depending on the phase.

19.2.1.6 Materials

Estimated amounts of materials required, as well as waste removed during the various phases of the EIPC project, are discussed below.

19.2.1.6.1 Construction

Heavy equipment estimated for construction activities includes one or more of the following:

- Asphalt-paving machine
- Backhoe
- Bulldozer
- Concrete finisher
- Concrete pumper
- Concrete truck

- Cherry picker
- Smooth compactor
- Plate compactor
- Sheep-foot compactor
- Concrete saw
- 100-ton crane
- 300-ton crane
- Digger-derrick
- Dump truck
- Earthmover
- Excavator
- Forklift
- Front-end loader
- Generator
- Lift-boom
- Power tool
- Scissor lift
- Track-hoe
- Trencher
- Semi-truck and trailer
- Welding machine
- Welding torch
- Well drill

An estimated 30,200 truck deliveries are required during construction activities, including approximately 2500 concrete truck deliveries, 200 flatbed truck deliveries containing steel, 1800 base course dump truck deliveries, 2400 asphalt dump truck deliveries, 250 truck deliveries containing other building products, 22,850 deliveries of fill/spoils dirt, and 200 deliveries of commercial waste. Approximately 308,100 gallons (gal.) (1,166,300 liters [L]) of gasoline fuel and 452,900 gal. (1,714,400 L) of diesel fuel are expected to be consumed during construction.

Construction includes building the PWH, AOC, ACC, POC; the EMIF, including EMIF and target fabrication area equipment (if target fabrication occurs on-site); waste storage equipment; and support equipment. Construction also includes the delivery of initial processing glassware and process chemical materials. The initial delivery includes product shipping containers and waste storage drums.

The estimated quantities of materials that are consumed during the construction phase are provided in Table 19.2.1-1.

During this period, construction waste is removed from the project site on a regular basis and delivered to the local landfill. EIPC construction waste represents a small fraction of what the local landfill handles on an annual basis from potential industrial contributors in the Lea County area (SWF, 2015).

19.2.1.6.2 Pre-Operations

Based on the preoperational activities identified in Subsection 19.2.1.2.3, there is no heavy equipment required during preoperational activities and no significant waste generated during this phase. Shipments during the preoperational phase are predominately equipment shipments, totaling 115 shipments of equipment and 14 waste shipments (8 total shipments per month). Approximately 300,100 gal. (1,136,000 L) of gasoline fuel and 6000 gal. (22,700 L) of diesel fuel are expected to be consumed during pre-operations.

19.2.1.6.3 Operation

After issuance of the OL and the 10 CFR Part 70 license, fully fabricated targets are either delivered to the site from a target fabrication vendor in approved shipping containers, or targets are fabricated on-site in the target fabrication area of the EMIF using LEU supplied by the DOE.

The volume and rate of delivery and shipment of materials depends on early production levels. It is expected that the initial production levels of Mo-99 per week are significantly less than the U.S. demand. At full U.S. demand, approximately 30 targets are processed per week with the reactor operating at 1.8 megawatts thermal (MWt). At production levels less than the U.S. demand, the reactor power level could be less than 1.8 MWt and/or the number of targets processed could be adjusted.

The process waste is neutralized, solidified, and stored in 55-gal. (208 L) waste drums for radioactive decay and subsequently shipped to a disposal site as LLW. At 100 percent U.S. demand for Mo-99, the number of waste drums generated is approximately eight drums per week.

The products extracted and purified during processing are packaged in approved shipping container(s) and shipped to the customer. At 100 percent U.S. demand, Eden anticipates up to nine shipments of Mo-99 product per week. Additional fission products, I-131 and Xe-133, as well as activation products (e.g., Lu-177), are shipped in approved containers as dictated by product demand.

Eden projects an estimated 10,500 product deliveries during the 40-year OL, along with 3600 off-site waste shipments. Approximately 810,850 gal. (3,069,400 L) of gasoline fuel and 105,700 gal. (400,100 L) of diesel fuel are expected to be consumed during operations.

All the targets in the reactor are processed for Mo-99 production. Because the reactor type is all-target, there is no spent fuel or high-level waste generated in the EMIF.

Nonradioactive, nonhazardous waste is disposed of at the local landfill.

19.2.1.6.4 Decommissioning

At the end of the EIPC’s useful program life, the EIPC is decontaminated and decommissioned. All targets have been processed when the site decommissioning phase commences. Remaining

SNM is returned to DOE prior to the start of decommissioning activities or is disposed of as radioactive waste during decommissioning. During decommissioning, the only wastes disposed of are any remaining process-wastes, as well as legacy contaminated materials and equipment. The site is either returned to its near-original state or reused for other applications. The total number of truck deliveries is approximately 9600, which includes 100 truck deliveries for heavy equipment (mobilization/demobilization), 9250 truck deliveries for off-site waste shipments, and 250 truck deliveries for construction materials and commodities. The monthly average of off-site waste shipments is 400 roundtrip truck deliveries, with a monthly peak of 650 roundtrip truck deliveries. The post-operational decommissioning activities require approximately 13,750 gal. (52,050 L) of diesel fuel per month.

The evaporation pond is designed and permitted in accordance with all applicable New Mexico regulations. Testing of the pond is performed as required by all applicable New Mexico regulations. No additional decommissioning excavation of the evaporation pond is anticipated; however, any indications of hazardous chemicals in the soil are remediated in accordance with the Resource Conservation and Recovery Act (RCRA), and the evaporation pond is backfilled.

Heavy equipment estimated for post-operational decommissioning activities include one or more of the following:

- Backhoe/loader
- Boom lift
- Lattice boom crane
- Picker crane
- Material truck
- Motor grader
- Pickup truck
- Dual-axel dump truck
- Excavator
- Extended forklift
- Fuel truck
- Skidsteer loader
- Tracked dozer
- Tracked loader
- Soil compactor
- Water truck
- Portable air compressor
- Portable generator
- Portable welder/torch cutter
- Walk-behind compactor

Table 19.2.1-1
Estimated Construction Material Quantity Needs

Material	Amount[(a)]
Concrete	26,640 yd^3
Structural steel	2600 T
Asphalt	12,900 yd^3
Stone granular material	10,800 yd^3
Roofing	432 T
Equipment	120 T
Fencing	15,600 ft.

a) These quantities include a margin of approximately 20 percent for conservatism.
Abbreviations: yd^3 = cubic yard(s) | T = ton(s) | ft. = feet

19.2.2 SITE LOCATION AND LAYOUT

19.2.2.1 Site Location

The site centerpoint is located about 1.4 mi. (2.2 km) east of Eunice, NM, near the New Mexico–Texas state line in Lea County, NM (see Figure 19.2.1-1) (NM RGIS, 2021; ESRI, 2022; GIS, 2021; USGS, 2019). The EIPC project site is on the south side of NM-176.

19.2.2.1.1 Nearby Towns and Inhabitants

The nearby towns and counties, as well as the respective distances from the EIPC project site to the town and county borders are provided in Table 19.2.2-1.

19.2.2.1.2 Sensitive Populations

The sensitive populations located within 5 mi. (8 km) of the EIPC project site (measured from the site centerpoint) are provided in Table 19.2.2-2. The listed sensitive populations are located northwest of the site in Eunice, NM. There are no other sensitive population establishments within a 5-mi. (8-km) radius of the project site.

19.2.2.1.3 Landmarks

No historical landmarks are identified within a 5-mi. (8-km) radius of the EIPC (NPS, 2022; NMHPD, 2022; THC, 2022; USGS, 2022). Significant nearby highways and roadways are shown in Figure 19.2.1-1. The site centerpoint is located approximately 0.6 mi. (0.9 km) south of NM-176 and approximately 1.7 mi. (2.8 km) east of New Mexico Highway 18 (NM-18) (NM RGIS, 2022; ESRI, 2022; GIS, 2021; USGS, 2019). The nearest commercial airport is approximately 19.5 mi. (31.4 km) to the northwest (just west of Hobbs, NM) (NM RGIS, 2021; ESRI, 2022; GIS, 2021; USGS, 2019).

As shown in Figure 19.2.1-1, NM-176 passes along the northern boundary of the EIPC project site with Eunice, NM, 1.4 mi. (2.2 km) to the west of the site centerpoint and the New Mexico–Texas state line 1.9 mi. (3.1 km) to the east (USCB, 2021; NM RGIS, 2021; ESRI, 2022; GIS, 2021; USGS, 2019; Data.gov, 2017). NM-176 becomes TX-176 at the state line, continuing 30 mi. (48 km), by road, eastward to Andrews, TX. The location of surface water features in the vicinity of the site is discussed in Subsection 19.3.4.1.

NM-176 provides direct access to the EIPC project site; it is a two-lane highway that widens at the URENCO facility location to provide acceleration and deceleration lanes in both directions for the two site entrances. About 1.8 mi. (2.9 km) to the west of the site centerpoint, NM-176 intersects NM-18, which runs 18 mi. (29 km) north to Hobbs, NM, and 23 mi. (37 km) south to Jal, NM (NM RGIS, 2022; ESRI, 2022; GIS, 2021; USGS, 2019). NM-18 is a four-lane divided highway that crosses south into Texas (becoming TX-18), and connects with Interstate 20 (I-20) in Monahans, TX, 66 mi. (107 km) south of its intersection with NM-176 by road.

19.2.2.2 Latitude and Longitude

The centerpoint of the site is latitude 32° 25’ 25.44” N latitude, and 103° 5’ 46.14” W longitude.

19.2.2.3 Size and Layout

The EIPC project area consists of 245.6 ac. (99 ha), of which approximately 55.7 ac. (22.5 ha), or 22.7 percent, is expected to be permanently disturbed, and approximately 37.5 ac. (15.2 ha), or 15.3 percent, is expected to be temporarily disturbed. Additionally, approximately 33.2 ac. (13.4 ha) is expected to be temporarily disturbed for the off-site utility corridor. The layouts of the project site and off-site utility corridor are shown in Figure 19.2.1-4 and Figure 19.2.1-3.

19.2.2.4 Infrastructure Improvements

The EIPC requires the installation of electrical service lines, a potable water supply pipeline, and a sanitary waste pipeline.

19.2.2.4.1 Electrical Power

Most of the electrical power required by the EIPC is used to power the RF, HCF (including the target fabrication area), storage spaces, office spaces, and external lighting and security systems. The EIPC is estimated to consume 26,284 megawatt-hours per year in total electrical energy. A new electrical substation and distribution line provide electrical service to the facility.

Currently, high capacity electric transmission lines run east-west less than 200 ft. (61 m) north of the project site border. Eden connects to the high capacity transmission lines to provide electrical service for the EIPC project site. A 10-megavolt-ampere substation and distribution line, installed by the local electric utility, supplements the existing infrastructure. The substation is within the owner-controlled area (OCA) fence, but outside of the operations boundary fence. To support essential loads, standby diesel generators and uninterruptible power supply systems are provided. One or more double-walled diesel fuel storage tank(s) located near the standby diesel generator systems, either underground or aboveground provides fuel to the standby diesel generators. The diesel fuel storage tank provides 8000 gal. (30,300 L) of standby diesel generator fuel storage for up to 72 hours of operation.

19.2.2.4.2 Water

The project site requires water for cooling, landscaping, sanitary use, and makeup for plant water systems such as fire protection.

The potable water supply pipeline is connected to the existing City of Eunice water supply line, immediately east of NM-18, and has sufficient capacity to support the EIPC.

19.2.2.4.3 Sewer

19.2.2.4.3.1 Storm Sewers and Stormwater Collection Basins

The EIPC stormwater system within the facility's boundary is designed for a 100-year rainfall event. The external runoff is collected in the peripheral interceptor ditches, which are designed to be adequate for an LIP rainfall event. The rainfall intensity was obtained from the National Oceanic and Atmospheric Administration for the Hobbs/Eunice, NM, area.

The storm sewer systems — located within the operations boundary, within the permanent parking area, and in a portion of the construction laydown area — collect runoff from roadways, building roofs, parking areas, and pads. This runoff is discharged to the stormwater retention

pond located to the west of the EIPC structures. The retention pond mitigates any adverse impacts of post-developed stormwater runoff on the existing natural drainage courses and on the facility's infrastructure during the plant's operational life. Stormwater runoff from outside the operations boundary and a portion of the construction laydown is collected by the interceptor ditches and is directly discharged to the existing natural drainage courses southwest of the project site via level spreaders. These level spreaders mitigate any adverse impact to the natural drainage courses.

The EIPC buildings, storage, construction laydown, parking, and other miscellaneous structures/areas have interceptor ditches at the upstream side of the site. External runoff is intercepted by these ditches, and the flow is directed to the natural drainage courses, which slope towards brushland to the southwest. The flow is dispersed by a level spreader to prevent downstream erosion. The stormwater system, within the project site, is designed for 25-year and 100-year rainfall events as required by Lea County, NM. The design also addresses the requirements of New Mexico state regulation by checking the design for two-year, 24-hour storm events for water quality purposes.

No 100-year floodplains exist within the EIPC project area; furthermore, the area is not located within any "special" flood hazard area. Its flood hazard classification is designated as an area of undetermined flood hazard (Zone-D) per the Federal Emergency Management Agency National Flood Hazard Layer FIRMette (FEMA, 2021). Design features — such as locating the interceptor drainage ditches on the upstream side, locating building structures sufficiently above grade to keep them above the 100-year runoff depth, and installing sump pumps in the buildings — help protect structures from flooding due to design-basis storm events.

19.2.2.4.3.2 Sanitary Sewer

Normal sanitary wastewater is sent to the City of Eunice wastewater treatment plant for processing. A system of lift stations and pipelines is installed to connect to the existing wastewater treatment plant, west of NM-18.

19.2.2.5 Buildings and Areas

A layout of the EIPC is shown in Figure 19.2.1-4. The principal buildings, structures, and spaces are the following:

- AOC
- ACC
- POC
- PWH
- EMIF, which includes the following areas:
  - RF:
    - RF high bay.
    - Reactor pool.
    - Reactor control room.
    - Other miscellaneous rooms.

  - HCF:
    - HCF target processing high bay.
    - Waste storage canyon.
    - Target fabrication area.
    - AIP area.
    - HCF target processing canyon.
    - Transfer canal (shared with RF).
    - Other miscellaneous rooms.
  - Other Spaces:
    - Liquid effluent control system (LECS).
    - Entrance.
    - Lobby.
    - Hallways.
    - Elevators.
    - Stairwells.
    - HCF second floor.
- Other site spaces/areas:
  - Cooling towers for the reactor secondary coolant system.
  - Heating, ventilation, and air-conditioning (HVAC) air cooled chillers.
  - Electrical substation.
  - Standby diesel generators with fuel tank.
  - Diesel pump (firewater).
  - Firewater tank.
  - Liquid nitrogen (LN2) tank and vaporizers.
  - Asphalt parking area.
  - Asphalt road.
  - Access road.
  - HCF truck terminal ramps.
  - Stormwater runoff pond.
  - Evaporation pond.
  - Drainage channels.
  - Operations boundary fence.
  - OCA fence.

19.2.2.6 Underground Systems

The systems at the EIPC project site that have components underground are:

- A double-walled diesel fuel storage tank(s) near the standby diesel generator systems (backup power), providing 8000 gal. (30,300 L) of standby diesel generator fuel storage for up to 72 hours of operation. The storage tank(s) may be located either underground or aboveground.
- An underground wastewater pipeline system with a lift station, which carries normal sanitary wastewater from the EIPC to the Eunice, NM, municipal wastewater treatment facility.
- An underground insulated pipe may be used to supply LN2 from a storage tank to the HCF.
- A separate underground pipeline system that carries wastewater from EMIF decontamination stations, laboratory spaces, and floor drains where radioactive and/or hazardous materials are present in an on-site LECS equipped with leak detection.
- An additional underground wastewater pipeline system to route cooling tower blowdown and LECS discharge to the evaporation pond.
- A water line connecting the Eunice, NM, water system that provides water to the EIPC.
- The electrical distribution line from the electrical substation to each load within the EIPC. The electrical substation is within the OCA fence, but outside of the operations boundary fence.
- Portals, raceways, and cabling for voice and broadband data, telephone service, on-site communication, instrumentation monitoring, and security.
- Underground pipeline system that carries stormwater to the retention pond.

19.2.2.7 Monitoring Stations

Environmental monitoring stations, as listed below, are positioned at various appropriate locations on the EIPC project site (i.e., included within the security fence) as well as on-site within the exclusion area boundary and other required locations off-site. The need for monitoring stations is discussed in the following sections of this ER:

- Air monitoring – Section 19.4.2.
- Groundwater monitoring – Section 19.4.4.
- Surface-water monitoring – Section 19.4.4.
- Meteorological monitoring – Section 19.4.2.
- Ecological monitoring – Section 19.4.5.
- Radiological monitoring – Section 19.4.8.

Table 19.2.2-1
Towns and Counties in Affected Area

Town	Eunice, NM[a]	Hobbs, NM[b]	Jal, NM[c]	Lovington, NM[b]	Lea County, NM[b]	Andrews, TX[b]	Andrews County, TX[b]
Distance and direction from site Center[d]	1.4 mi. west	17 mi. northwest	20 mi. southwest	32 mi. northwest	N/A	30 mi. southeast	1.9 mi. east
Total population	3144	40,508	2185	11,668	74,455	13,487	18,610
Female population	1529	19,120	995	5939	36,185	6770	9082
Male population	1508	21,388	901	5729	38,270	6717	9528

a) Source: WPR, 2021a.
b) Source: USCB, 2020.
c) Source: WPR, 2021b.
d) Sources: NM RGIS, 2021; Data.gov, 2017; ESRI, 2022, GIS, 2021; USGS, 2019.
Abbreviations: NM = New Mexico | TX = Texas | RF = Reactor Facility | mi. = mile(s)

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Table 19.2.2-2
Sensitive Populations Within 5 Miles of Site

Facility Type	Location of Interest	Distance
Religious	First Christian Church	3.5 mi.
	First Assembly of God	3.5 mi.
	Eunice First Holiness Pentecostal Church	3.6 mi.
	First Baptist Church	3.7 mi.
	First United Methodist Church	4.0 mi.
	Trinity Holiness Church	4.1 mi.
Park	Municipal Park	3.8 mi.
Medical	Eunice Health Clinic	3.9 mi.
Law Enforcement	Eunice Police Department	4.6 mi.
Educational	Caton Middle School	4.1 mi.
	Eunice Holiness Academy	4.1 mi.
	Mettie Jordon Elementary School	4.2 mi.
	Eunice High School	4.2 mi.

Abbreviations: mi. = mile(s)

19.2.3 REACTOR FACILITY

The EIPC provides the U.S. medical community with a reliable supply of Mo-99 and other isotopes required for nuclear medicine. Eden induces fissions in LEU and extracts Mo-99, I-131, and Xe-133 produced as fission products in the irradiated LEU (NASEM, 2016), as well as activation products, such as Lu-177.

The EMIF consists of an RF and an HCF that are contiguous and separated by a shared wall to maintain separate confinement control. The RF and HCF have separate ventilation systems, including separate exhaust stacks.

The RF consists of a high bay containing the reactor, reactor pool, transfer canal (shared with the HCF), reactor cooling system room, and reactor high bay ventilation system room. The RF also houses the reactor control room, LECS room, and various other rooms.

The HCF consists of a high bay containing the target processing canyon. Within the HCF are other support rooms and areas, including the target fabrication area, equipment storage rooms, maintenance rooms, shipment rooms, waste storage canyon, and cask loading bays.

19.2.3.1 All-Target Reactor Description

The all-target reactor is an open-pool system with the reactor core approximately 24 ft. (7.3 m) below the reactor pool water level surface. The reactor core is a hexagonal array of targets that is surrounded by an annular beryllium (Be) reflector region. The assembly, including the reflector region, is approximately 24 inches (60 centimeters [cm]) tall and approximately 1.5 ft. (0.5 m) in diameter. Normal operations are with a 60-target configuration. The four control rods are located at four corner locations in the first row of the Be reflector matrix. The reactor is operated at prescribed power levels up to 1.8 MWt.

Each target contains LEU, with an enrichment of approximately 19.75 percent at initial loading. The cladding is aluminum (Al). The LEU foil is separated from the Al by a nickel (Ni) recoil barrier to minimize fission fragment bonding.

The reactor is designed such that the individual target can operate at an average thermal power level of 30 kilowatts thermal. The targets are convection-cooled by natural circulation of the reactor coolant. The reactor pool contains deionized (greater than 1.0 megaohm-cm) water. The large volume of water in the pool allows for no additional cooling requirements with the reactor shutdown.

19.2.3.2 Reactor Fuel Usage

The 60-target configuration uses 30 targets per week to meet 100 percent U.S. demand for Mo-99. With reclamation and reuse of the LEU for targets, the LEU recovery is approximately 90 percent of this throughput value.

19.2.3.3 Reactor Operation

The reactor is operated continuously except for short downtime periods for withdrawal of irradiated targets for processing and placement of fresh targets into the core. The exposed targets are transferred to the transfer canal during downtime. Also, during downtime periods,

inspections and routine maintenance are performed, and periodic downtime is planned for more extensive inspection and maintenance.

19.2.3.4 Reactor Coolant System

The reactor primary coolant system is designed to maintain reactor coolant temperature while conservatively transferring at least 1.8 MWt to the reactor secondary coolant system. The system consists of piping to circulate reactor coolant from the reactor pool through a heat exchanger, wherein the reactor coolant heat is transferred to the reactor secondary coolant system that discharges its heat to the atmosphere via evaporation in the two cooling towers for the reactor secondary coolant system outside the RF. One tower is necessary for full power operation. With both primary and secondary cooling loops operating, the secondary cooling water loop is maintained at a higher pressure than the primary coolant loop to minimize the potential of primary coolant escaping into the secondary cooling water. The reactor primary coolant cleanup system employs a hydrogen (H)/ hydroxide (OH) mixed-resin bed demineralizer to maintain acceptable water quality for the reactor pool, transfer canal, and the reactor primary coolant cleanup system. The demineralizer resins are replaced at the end of life, rather than regenerated on-site. At the end of life, the demineralizer resins contain some radionuclide loading and are disposed of as LLW, with a classification of Class A (see Section 19.2.8). The secondary coolant water chemistry is maintained to prevent scaling and deposition and corrosion or degradation of metal parts within the secondary coolant system. The simplified water balance shown in Figure 19.2.3-1 includes additional detail.

19.2.3.5 Reactor Facility High Bay Ventilation System

The RF high bay ventilation system provides an elevated outdoor stack for the controlled release of radionuclides escaping the pool into the RF high bay. The exhaust system is normally operating when the reactor is operating and when targets are being moved from the reactor to the HCF. Small quantities of argon-41 and tritium are released from the pool surface during normal operations and monitored through the RF high bay ventilation system. The system (see Figure 19.2.3-2) maintains a negative pressure in the RF with respect to the external environment, including the office spaces. It is normally operated in an unfiltered mode but can be switched to a filter mode by the operator based on continuous-air monitor (CAM) signals from the stack exhaust. The system is not credited in the maximum hypothetical accident or other accidents.

19.2.4 HOT CELL FACILITY

The irradiated targets are retrieved from the reactor core and transferred underwater to the transfer canal where, after an appropriate time for decay of the radionuclides and attendant fission product heating, the targets are then transferred underwater to the HCF target processing canyon.

In the HCF target processing canyon, the LEU foil is mechanically extracted from the target and dissolved in acid. Both I-131 and Xe-133 can be captured and packaged for market from the dissolver off-gas. Mo-99 is chemically extracted from the resultant solution and refined using the modified Cintichem process. The LEU is recovered from the remaining solution using a uranium extraction (UREX) process. The raffinate from the UREX process, which contains the waste fission products and actinides, is solidified in a grout mixture and packaged in a waste drum. The LEU in the form of uranium oxide (U_3O_8) is recycled for use within the EMIF target fabrication area. In the target fabrication area, the material is converted to a metal ingot and reformed into a foil for reuse in new targets.

With regard to specific chemical applicability and treatments within the processing line, various chemical solutions are deployed in the HCF (including the target fabrication area) to support the following activities:

- Dissolution of irradiated target LEU foils.
- Purification of Mo-99.
- Capture of I-131 or other fission product gases with traps.
- Extraction of LEU with the UREX process.
- Calcining of uranyl nitrate from UREX to U_3O_8.
- Reduction of U_3O_8 to U metal.

These activities are performed in steel confinement boxes (SCBs) located in the HCF target processing canyon, except for the reduction of U_3O_8, which is performed in the target fabrication area (if targets are fabricated on-site). The SCBs are designated by their functions, including the dissolver box, purification box, or UREX box.

The main chemicals that are used in the dissolver boxes, UREX boxes, and purification boxes are:

- Nitric acid (HNO_3)
- Acetohydroxamic acid (AHA)
- Sodium hydroxide (NaOH)
- Nitrogen (N_2)
- Oxygen (O_2)
- Sulfuric acid (H_2SO_4)
- Alpha benzoin oxime (ABO)
- Silver nitrate ($AgNO_3$)

- Hydrogen peroxide (H_2O_2)
- Hydrochloric acid (HCl)
- Potassium hexachlororuthenate (K_3RuCl_6)
- Potassium permanganate ($KMnO_4$)
- Sodium iodide (NaI)
- Rhodium chloride trihydrate ($RhCl_3H_6O_3$)
- Tributyl phosphate (TBP)
- Dodecane

The estimated quantities of chemical solutions that are used in a dissolver box, UREX box, purification box, and U-metal line in the target fabrication area to process 2000 target foils are provided in Table 19.2.4-1.

No bulk chemical preparation or bulk chemical storage is performed or located in the HCF. Bulk chemical storage and preparation of the dissolution, carrier, and purification solutions are performed in the POC or PWH outside the HCF.

Kits are prepared in the POC or PWH for each batch of targets for the activities associated with each SCB. The kits associated with the day's activities are delivered to the HCF prior to the commencement of the processing activities. The kits are identified as unique to each activity and include chemical solutions, hardware, and other materials required to perform the activity.

Most chemicals are consumed during the activities within the SCB. The exception is the TBP/dodecane — which remains in the UREX box and is reused until it is degraded and disposed of — and the excess HNO_3 in the UREX process raffinate. No chemicals are removed from the HCF target processing canyon without being processed as waste. Chemical solutions are solidified in a grout or other approved waste solidification form and placed in a 55-gal. (208-L) drum.

19.2.4.1 Hot Cell Facility Description

The HCF consists of multiple spaces used for preparing and processing unique materials. The HCF contains a high bay region with a shielded processing canyon (the HCF target processing canyon). This canyon contains the material processing and waste preparation box line. Additionally, the HCF provides various spaces for the required processing support functions, such as those for personnel access, work and changing, equipment storage, maintenance, shipping and receiving, inspection and quality control (QC), and the target fabrication area. The HCF also includes a basement for the long-term staging of full waste drums within a shielded canyon (the waste storage canyon), an AIP area, and additional storage space for equipment and process waste drums.

Targets irradiated in the reactor are transferred underwater via the transfer canal to the receipt box in the HCF target processing canyon. Target processing is performed remotely in this heavily radiation-shielded canyon area, which contains separate SCBs dedicated to different functional stages of the Mo-99 extraction process.

A target fabrication area is included in the HCF. Target fabrication, if it occurs on-site, consists of blending the recycled oxide of SNM with fresh target material, rolling and forming the material into Ni-coated foil, and cladding the foil with Al to create new targets.

The waste storage canyon in the HCF basement provides adequate space for the long-term on-site storage/decay of waste drums. These drums contain process waste, which has been neutralized and then solidified with other waste generated in the hot cells and stored in waste drums for radioactive decay. These waste drums are subsequently shipped to a disposal site as LLW.

The HCF basement has an AIP area. This area has a shielded glovebox line to allow for AIP target dissolution, product purification, product packaging, and parent material recovery.

19.2.4.2 Process-Line Description

Processing is done in the SCBs within the HCF target processing canyon.

The transfer of materials between the individual SCBs is facilitated by a dedicated transfer system.

19.2.4.3 Waste Handling

The process waste solution is neutralized and solidified in a solidified waste form and placed into a storage drum that, when fully loaded, is moved remotely (by elevator) to the basement waste storage canyon. After a period of decay, the waste drums are shipped to a waste disposal site and disposed of as Class C or lower LLW.

19.2.4.4 Hot Cell Facility Ventilation System

Each SCB has an inlet and exhaust filter. Exhaust from SCBs 2-7 are manifolded together and routed through a high-efficiency particulate air (HEPA) and charcoal filter bank before being discharged to the outside environment through the HCF Zone 1a exhaust stack. SCBs 1 and 8 – 19 are manifolded together and routed through a HEPA and charcoal filters bank before being discharged to the outside environment through the HCF exhaust stack. This is shown schematically in Figure 19.2.4-1. The major potential radioactive effluents are noble gases and volatile species, such as xenon and iodine.

Some of the halogens, primarily iodine, may form chemical species and be entrained in the product solution after dissolution. This iodine may evolve from the solution during processing and be captured in the SCB charcoal filter or ventilation filter.

Table 19.2.4-1
Estimated Annual Quantities of Chemicals to Process 2000 Targets

Chemical	Dissolver Annual Quantity	Purification Annual Quantity	UREX Annual Quantity	U-Metal Annual Quantity	Facility Annual Quantity
0.5-M AHA in 0.1M HNO_3	–	–	106 L (28 gal.)	–	106 L (28 gal.)
TBP in n-dodecane	–	–	356 L (94 gal.)	–	356 L (94 gal.)
Ca (s)	–	–	–	92,514 g (3263 oz.)	92,514 g (3263 oz.)
H_2SO_4 –18.4M	–	0.5 L (0.13 gal.)	–	–	0.5 L (0.13 gal.)
HNO_3 –15.8M	352.8 L (93.2 gal.)	133.4 L (35.2 gal.)	76.5 (20.0 gal.)	–	562.7 L (148.6 gal.)
LN2 (l)	200,000 L (52,900 gal.)	–	–	–	200,000 L (52,900 gal.)
NaOH –19.4M	52.99 L (14.0 gal.)	14.514 L (3.83 gal.)	–	–	67.5 L (17.8 gal.)
[a]ABO(s)	–	4680 g (165 oz.)	–	–	4680 g (165 oz.)
[a]HCl –12.1M	–	1.0 L (0.26 gal.)	–	–	1.0 L (0.26 gal.)
[a]H_2O_2	–	0.213 L (0.056 gal.)	–	–	0.213 L (0.056 gal.)
[a]$KMnO_4$ (s)	–	200 g (7.05 oz.)	–	–	200 g (7.05 oz.)
[a]$RhCl_3H_6O_3$ (s)	–	477.4 g (16.8 oz.)	–	–	477.4 g (16.8 oz.)
[a]K_3RuCl_6 (s)	–	660 g (23.3 oz.)	–	–	660 g (23.3 oz.)
[a]$AgNO_3$ (s)	–	831.4 g (29.3 oz.)	–	–	831.4 g (29.3 oz)
[a]NaI (s)	–	146.9 g (5.18 oz.)	–	–	146.9 g (5.18 oz.)
O_2 (g)	66,000 L (17,435 gal.)	–	–	–	66,000 L (17,435 gal.)

a) These chemicals are considered carrier solutions used in the Mo-99 purification process.
Abbreviations: M = molarity | AHA = acetohydroxamic acid | HNO_3 = nitric acid | L = liter(s) | gal. = gallon(s) | TBP = tributyl phosphate | Ca = calcium | s = solid | g = gram(s) | oz. = ounce(s) | H_2SO_4 = sulfuric acid | LN2 = liquid nitrogen | NaOH = sodium hydroxide | ABO = alpha benzoin oxime | HCl = hydrochloric acid | H_2O_2 = hydrogen peroxide | $KMnO_4$ = potassium permanganate | $RhCl_3H_6O_3$ = rhodium chloride trihydrate | K_3RuCl_6 = potassium hexachlororuthenate | $AgNO_3$ = silver nitrate | NaI = sodium iodide | O_2 = oxygen

19.2.5 WATER CONSUMPTION AND TREATMENT

Water is supplied by the municipal authority. Water to serve personnel (i.e., water closets, lavatories, drinking fountains, and service sinks) and for small ancillary services is supplied as potable water from the municipal authority. This water does not receive further treatment at the facility. Wastewater is returned to the municipal water system. Water treatment for the makeup associated with losses due to mechanical-draft cooling tower (MDCT) evaporation, blowdown, and drift is discussed in Subsection 19.2.6.2, and a water balance diagram is provided in Figure 19.2.3-1. The EIPC requires approximately 20.2 million gallons per year (MGPY) (76.5 million liters per year [MLPY]) of water to satisfy requirements for cooling tower makeup, sanitary water, and landscaping. The cooling towers for the reactor secondary coolant system require 13.5 MGPY (51.1 MLPY) of makeup and is positively correlated to the power at which the reactor is operated. Approximately 0.032 MGPY (0.012 MLPY) are required for makeup to the reactor primary coolant system. Sanitary water requirements for water closets, lavatories, drinking fountains, and service sinks are estimated to be 5.7 MGPY (21.6 MLPY). Sanitary wastewater is discharged to the City of Eunice's wastewater treatment plant. An additional 0.9 MGPY (3.4 MLPY) is estimated to be required for landscaping. The reactor coolant is cycled through a demineralizer to remove minerals and to maintain proper pH/resistivity.

19.2.6 COOLING AND HEATING DISSIPATION SYSTEM

19.2.6.1 Description

The primary cooling systems for the EMIF are the following:

- Reactor secondary coolant system: removes heat from the reactor primary coolant system.
- HCF ventilation and general area HVAC systems: removes heat generated in the HCF facility due to operating equipment and electrical loads.
- RF high bay and general area HVAC systems: removes heat generated in the RF high bay and the reactor control room due to operating equipment and electrical loads.

19.2.6.1.1 Reactor Secondary Coolant System

The reactor secondary coolant system removes heat in the reactor primary coolant system through the reactor coolant heat exchangers. The heat in the secondary coolant system is ultimately rejected to the environment using MDCTs outside the RF. Each cooling tower for the reactor secondary coolant system is conservatively sized to reject 2 MWt of heat. Only one tower is necessary for full power operation. Table 19.2.6-1 provides the sizing basis for the cooling towers based on a design wet-bulb temperature of 73 degrees Fahrenheit (22.8 degrees Celsius).

The total water usage for the cooling towers for the reactor secondary coolant system is shown in the EIPC water balance (see Figure 19.2.3-1). This water usage is conservatively based on a reactor heat load of 2 MWt. See Figure 19.2.1-4 for the locations of the cooling towers for the reactor secondary coolant system.

Blowdown from the cooling towers, along with drains from the LECS, are routed to the evaporation pond where the water is evaporated to the atmosphere. The cooling tower blowdown is approximately 8.51 gallons per minute (gpm) (32.2 liters per minute [lpm]) including margin.

The evaporation pond also collects wastewater (approximately 0.03 gpm [0.11 lpm]) from the LECS tanks. Areas where radioactive or hazardous materials may be present, including floor drains in the RF and HCF and emergency showers in the HCF, are connected to the LECS. The wastewater from the LECS is monitored to ensure that the water meets regulatory requirements before release.

The evaporation pond is sized to ensure all the influent is evaporated in a timely manner for the facility to function continuously. The total storage capacity of the evaporation pond is approximately 13 acre-feet (16,040 m^3), with a bottom length of 620 ft. (189 m), a bottom width of 315 ft. (96 m), and a depth of 6 ft. (1.8 m). The total depth includes 3 ft. (1 m) of freeboard depth to ensure that the evaporation pond does not overflow during a Probable Maximum Precipitation event as well as the inflow due to a 100-year storm event.

A discharge permit will be obtained from the New Mexico Environment Department's Ground Water Quality Bureau, and construction and operation of the evaporation pond will follow all requirements of the permit. Additional monitoring may be needed, as determined by the permit requirements.

19.2.6.1.2 HCF and RF HVAC Systems

The HCF and RF HVAC systems remove heat generated from operating equipment and electrical loads from both the HCF and RF, respectively. This heat is ultimately rejected to the ambient using air-cooled chillers. See Figure 19.2.1-4 for the location of the air-cooled chillers for the HVAC systems.

19.2.6.2 Eden Radioisotopes Mechanical-Draft Cooling Tower Water Chemistry

Two cooling towers provide heat rejection for the reactor secondary coolant system and various potential mechanical heat loads. Each tower provides sufficient heat removal for full power operation.

Makeup is supplied as potable water by the municipal authority. The MDCTs operate between three and eight cycles of concentration based on: (1) maintaining the material condition of the MDCTs; (2) the cost of water; and (3) the cost of chemical additives. Blowdown is sent to the evaporation pond. Expected releases from the MDCTs are reviewed with the local and state authorities at the design stage.

Maintenance of MDCT water chemistry is contracted to a water treatment service provider, who will comply with federal, state, and local regulations.

Typical water treatment for the MDCTs includes an antiscalant, such as H_2SO_4, and a biocide, such as sodium hypochlorite (NaClO). Other MDCT treatment chemicals can include proprietary polymers, alternative biocides, such as chlorine dioxide (ClO_2), and anti-flocculants to avoid siltation (which is not expected for potable water makeup). The final approach to MDCT water treatment is based on that proposed by the service provider as reviewed and approved by Eden.

Table 19.2.6-1
Reactor Secondary Coolant System Cooling Tower Performance[a]

Heat Rejected	Total Cooling Water Flow	Hot Water Inlet Temperature	Cold Water Outlet Temperature	Evaporation Loss	Drift Loss	Blowdown
2 MWt	1354 gpm	95°F	85°F	12.55 gpm	0.07 gpm	6.21 gpm

a) Flow rates in Table 19.2.6-1 do not include the 36.5 percent margin indicated on Figure 19.2.3-1.
Abbreviations: MWt = megawatt thermal | gpm = gallons per minute | °F = degrees Fahrenheit

19.2.7 WASTE SYSTEMS

Waste generated at the facility during phases of construction, operation, and decommissioning may include radioactive, nonradioactive, and hazardous waste. Waste management systems provide mechanisms for the collection and disposition of the waste in accordance with applicable state, NRC, and other federal environmental regulations. The disposal of the waste occurs in permitted nonradioactive, nonhazardous, and hazardous waste disposal facilities and licensed radioactive waste disposal facilities.

19.2.7.1 Radioactive Waste Systems

Radioactive waste generation occurs during the operations phase and decommissioning phase. The following subsections describe the waste systems during the operations phase of the facility. These systems are designed to limit discharges of radioactive materials in accordance with 10 CFR Part 20. The methods employed for the controlled release of radioactive material are dependent primarily on the state of the material (i.e., solid, liquid, or gaseous). The type, composition, and estimated annual quantity of radioactive waste generated during operations is provided in Table 19.2.7-1.

The type, composition, and estimated annual quantity of radioactive waste generated during decommissioning is provided in Table 19.2.7-2.

19.2.7.1.1 Liquid Radioactive Waste Systems

Water potentially containing radioactive impurities is collected by a separate drain system and delivered to the LECS storage tanks, where it is monitored and treated to remove contaminants and ensure solubility before ultimately being discharged to the evaporation pond. Drains and sump pumps are used in the RF to control any leakage or overflow of water on the primary side of the system. Any water collected from the primary side of the coolant system is transferred to the LECS storage tanks outside the RF. Other potentially contaminated water sources are also transferred to the LECS from other parts of the EMIF, including the HCF. The water transferred to the LECS storage tanks is then sampled for radionuclides; moreover, the LECS can also utilize a suitable temporary skid-mounted cleanup system to decontaminate the water if needed. Once the water is verified in compliance with the evaporation pond discharge permit, the water is released to the evaporation pond.

In summary, the LECS design-basis functionality includes the following:

- Provides a location where any liquid water from the RF and HCF is collected, including water from the pool, reactor primary coolant system, or the HCF drains.
- Provides water collection tanks that can be sampled for radionuclide content prior to the release of the water to the evaporation pond.
- Reduces radionuclides from LECS storage tanks using a suitable temporary skid-mounted cleanup system if the water sampling results indicate that radionuclide content is above release limits.

19.2.7.1.2 Solid Radioactive Waste Systems

Solid radioactive waste systems provide for the collection, processing, packaging, and storage of wet and dry solid radioactive waste produced from normal facility operations and

maintenance. LLW is collected on-site and shipped to a licensed radioactive waste disposal facility.

Radioactive and contaminated wastes in solid form are sent for disposal in 55-gal. (208-L) drums, with the exception of: (1) equipment that does not readily fit in drums, including HEPA/high-efficiency gas absorber (HEGA) filters; and (2) miscellaneous wastes, such as personal protective equipment (PPE). Large equipment and HEPA filters are sent to disposal in boxes.

Waste volume minimization is accomplished through compaction of glassware and other compressible solids. The solidified process waste is in such a form as to minimize the number of waste drums needed.

19.2.7.1.2.1 Reactor Primary Coolant Cleanup System Waste

An H/OH mixed-resin bed demineralizer maintains acceptable water quality for the reactor pool, transfer canal, and the reactor primary coolant cleanup system. The reactor primary coolant cleanup system demineralizer resin contains some radionuclide loading and must be disposed of as LLW, which is likely classified as Class A (see Section 19.2.8).

19.2.7.1.2.2 Hot Cell Facility Waste

HCF target processing canyon waste is neutralized, solidified, packaged in waste drums, and temporarily stored in the basement waste storage canyon. This also includes process hardware and glassware that is utilized within the HCF target processing canyon, such as target cladding and end fittings, dissolvers, glassware, and titanium dioxide (TiO_2) columns. It may be possible to decontaminate and reuse the end fittings. After an appropriate decay time, the waste drums are sent in approved transport containers to a waste disposal site as a Class C or lower LLW.

19.2.7.1.2.3 Miscellaneous Radioactive Solid Waste

Radioactive and/or contaminated hardware from areas outside the HCF target processing canyon, primary coolant or LECS (if generated) demineralizer resins, and HEPA/ HEGA filters are packaged and temporarily stored on-site until such time as they are disposed of at a waste disposal site as a Class A LLW. Some contaminated hardware may be decontaminated and reused. Contaminated PPE and other contaminated disposables are either decontaminated for reuse or packaged, temporarily stored on-site, then sent to a waste disposal site as Class A LLW.

19.2.7.1.3 Gaseous Radioactive Waste System

The facility is not expected to need a gaseous radioactive waste system. Any gaseous radioactive effluents generated are discharged through the RF high bay ventilation system and the HCF ventilation system. Releases to the atmosphere are controlled and monitored such that the total radiation exposure to persons outside the controlled area is As Low As Reasonably Achievable (ALARA) and does not exceed applicable regulations.

19.2.7.1.4 Radioactive Waste System during Decommissioning

During the decommissioning phase, contaminated PPE, rags, bags, and other laboratory and decontamination disposables are either decontaminated for reuse or packaged, temporarily stored on-site, and sent to a waste disposal site as Class A LLWs.

Additionally, radioactive and/or contaminated hardware, primary coolant or LECS (if generated) demineralizer resins, activated charcoal, and HEPA filter changeouts are temporarily stored on-site and sent to a waste disposal site as Class A LLWs.

Unsalvageable major hardware and windows are either decontaminated for nonradioactive disposal at the local landfill or packaged, temporarily stored on-site, and sent to a waste disposal site as Class A LLWs.

Contaminated concrete and soil are packaged, temporarily stored on-site, and sent to a waste disposal site as Class A LLWs.

19.2.7.2 Nonradioactive and Hazardous Waste Systems

During construction, routine operations, maintenance, cleaning, and decommissioning activities, both solid and liquid nonradioactive waste is generated at the EIPC.

The facility generates general types and quantities of nonradioactive and nonhazardous solid waste. No specific systems are planned other than waste management plans and policies that control nonradioactive and nonhazardous solid waste. Solid waste management and control measures for the facility include waste reduction, recycling, and waste minimization practices that are employed during all project phases (construction, operation, and decommissioning). Such wastes are managed in accordance with applicable federal, state, and local regulations.

The facility generates a variety of wastes that are classified as hazardous under the RCRA. These wastes include, but are not limited to, paint-related materials and spent solvents used for cleaning and degreasing, used oil, and antifreeze. The facility also generates universal waste, such as spent batteries and fluorescent lightbulbs. The facility is expected to be a small quantity generator of hazardous waste, with generation amounts considered to be insignificant during all phases, including construction, operation, and decommissioning. Scrap metal, universal wastes, used oil, and antifreeze is collected, stored, and recycled or recovered at an off-site permitted recycling or recovery facility, as appropriate.

Additionally, during operations, nonradioactive liquid waste may include hazardous waste such as chemicals used during operations. The chemical inventory is provided in Table 19.2.7-3. Small quantities of the liquid nonradioactive chemicals are released by the EIPC with the wastewater. The wastewater is discharged to the Eunice, NM, municipal wastewater treatment facility, and the EIPC ensures that its nonradioactive effluents meet the treatment facility's requirements regarding the effluent type, quantity, and concentration. Wastewater releases from the EIPC are controlled to meet federal, state, and local requirements. Small quantities of nonradioactive, hazardous wastes that cannot be released with the wastewater are stored in an appropriate location until they can be properly dispositioned.

19.2.7.3 Sources of Radioactive Waste Material

19.2.7.3.1 Sources of Radioactive Waste Material Within the Facility

Sources of radioactive solid, liquid, and gaseous waste material within the facility during operations are:

- Waste generated by the operation of the HCF target processing canyon and glovebox exhaust systems, including HEPA/HEGA filters.
- Waste generated by the operation of the RF HVAC system, including HEPA/HEGA filters.
- Spent demineralizer resin columns from the reactor primary coolant cleanup system water and the LECS wastewater.
- Routine or other LLW from maintenance activities.
- The purification process wastes, which consist of glassware, target cladding, end fittings, dissolvers, TiO_2 columns, and liquids that are combined with the UREX raffinate from the recovery of U for disposal as HCF target processing canyon waste when solidified.

19.2.7.3.2 Sources of Radioactive Waste Material at Nearby Operating Facilities

Sources of radioactive liquid, solid, and gaseous waste material at nearby operating facilities are discussed in Subsection 19.3.8.9.

19.2.7.4 Direct Radiation Sources

19.2.7.4.1 Direct Radiation Sources for Construction

The only direct radiation sources associated with construction are from typical construction activities, such as soil compaction density equipment and radiography for nondestructive examinations of piping and pressure vessels.

19.2.7.4.2 Direct Radiation Sources for Operations

Typical direct radiation sources associated with EMIF operations are:

- Reactor and reactor hardware.
- Reactor neutron source and calibration sources.
- Fission chambers, fission thermocouples (an intrinsically heated thermocouple used for neutron flux measurements), and dosimetry foils.
- Irradiated target during transfer.
- Enriched U.
- Targets and target materials in process.
- Process waste in process line and storage.
- Radioactive non-fuel hardware in storage.
- Medical isotope products.

- Primary coolant cleanup system demineralizer resins.
- LECS demineralizer resins (if generated).
- Ventilation system filters.

19.2.7.4.3 Direct Radiation Sources for Decommissioning

For decommissioning, the direct radiation sources are:

- Reactor hardware and systems, including pool liner, transfer canal liner, and supporting concrete and soil.
- Reactor neutron source and calibration sources.
- Fission chambers, fission thermocouples, and dosimetry foils.
- Reactor primary coolant system heat exchangers, pumps, and piping.
- LECS tanks and piping.
- Ventilation system filters and ductwork.
- Primary coolant cleanup system demineralizer resins.
- LECS demineralizer resins (if generated).
- Radioactive non-fuel hardware in storage.
- HCF contaminated structures and components.
- Processed waste in storage.

19.2.7.5 Radioactive and Nonradioactive Hazardous Materials

19.2.7.5.1 Radioactive Materials

19.2.7.5.1.1 Construction

During construction, sealed source radioactive isotopes are used in construction quality assurance (CQA) tasks associated with soil density (compaction) and weld quality. This equipment is typically licensed to the CQA Contractor and is handled in accordance with license requirements and standard procedures for each type of radioactive equipment.

19.2.7.5.1.2 Operations

With the exception of fresh targets, neutron sources, fission chambers, and calibration sources, most radioactive materials on-site are generated on-site. These include activation products, including actinides and fission products. Table 19.2.7-1 provides the type and annual quantity of radioactive material.

19.2.7.5.1.3 Decommissioning

Table 19.2.7-2 provides the type and annual quantity of radioactive material present during the decommissioning phase.

19.2.7.5.2 Nonradioactive Hazardous Materials

19.2.7.5.2.1 Construction

Integral to the multitude of construction processes that may be required to construct the EIPC are numerous materials that are considered hazardous under various safety and waste management regulations. These materials are in various forms, including solids, liquids, gases, vapors, fumes, dust, and mists. A brief, noncomprehensive summary of potential hazardous materials present during construction activities is provided in Table 19.2.7-4.

19.2.7.5.2.2 Operations

Table 19.2.7-3 provides the approximate bounding inventories of nonradioactive chemicals associated with the facility. Other hazardous materials include LN2, gases for cryogenics and provision for inert atmospheres, and certain cleaning solvents.

19.2.7.5.2.3 Decommissioning

Nonradioactive, hazardous materials present during decommissioning are considered similar to those present during construction.

19.2.7.6 Waste and Pollution Minimization

Radioactive waste volume minimization is directly proportional to Mo-99 production efficiency, final waste form density, and the number of targets processed. In general, Mo-99 production efficiency is achieved through design (maximum target fissions per gram of fuel) and the optimization of irradiation and process cycle time. Radioactive and/or contaminated materials are decontaminated and reused when practical.

Potential radioactive waste from decommissioning activities is considered for processing to reduce the amount of material that is disposed of as radioactive waste. Small particulate and gaseous effluents released through the HCF ventilation system are filtered via HEPA filters or, as necessary, HEGA (activated charcoal) filters to reduce radioactive species in exhaust streams to levels in compliance with 10 CFR Part 20. In the RF high bay, the exhaust system is normally operated in an unfiltered mode but can be operated in a filtered mode at the discretion of the reactor operator (see Subsection 19.2.3.5).

As described in NUREG/CR-5496, Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980 – 1996, combustion gas releases from the standby diesel generators and diesel-driven fire pump are small because of their infrequent use and, hence, low-duty cycle.

Nonradioactive waste (e.g., paper and plastic) is recycled in accordance with local processes.

Eden minimizes hazardous waste consistent with the requirements of 40 CFR 262.27 (the waste minimization certification).

Table 19.2.7-1
Types and Estimated Annual Quantities of Radioactive Wastes Generated During Operations

Description	Matrix	Class as Generated	Contents	Volume	55-gal. Drum Equivalent as Shipped
Process waste	Solid	C	Fission product raffinate waste immobilized in grout matrix along with target cladding, dissolvers, glassware, and TiO_2 columns that are used in the HCF processes	22,000 gal.	400
Wastewater	Liquid	LECS	Wastewater from equipment and labware decontamination other “hot” drains following ion exchange radionuclide removal	2334.4 gal.	N/A
PPE and anti-contamination clothing and materials	Solid	A	Contaminated PPE clothing and materials that require disposal	3080 gal.	56
Other LLW	Solid	A	Chemwipes, tape, plastic, and other items	880 gal.	16
Demineralizer resin	Solid	A	Demineralizer resin from the reactor primary coolant cleanup system and LECS (if generated) wastewater	425 L	3
HEPA and HEGA filters	Solid	A	Spent HEPA filters from the RF and HCF ventilation systems; HEGA filters where necessary to absorb certain chemical vapors (e.g., iodine and activated carbon)	80.5 ft^3 HEPAs 3.8 ft^3 HEGAs	N/A

Abbreviations: gal. = gallon(s) | TiO2 = titanium dioxide | HCF = Hot Cell Facility | LECS = liquid effluent control system | PPE = personal protective equipment | LLW = low-level waste | HEPA = high efficiency particulate air | RF = Reactor Facility | HEGA = high efficiency gas adsorption | ft^3 = cubic feet

Table 19.2.7-2
Types and Estimated Annual Quantities of Radioactive Wastes Generated During Decommissioning

Description	Matrix	Class as Generated	Contents	Quantity
Concrete	Solid	A	Structural concrete from the reactor pool and hot cells that may be radiologically contaminated	600 yd^3
Miscellaneous steel	Solid	A	Structural steel from the reactor pool and hot cells that may be radiologically contaminated	10 T
Steel liners	Solid	A	Steel liners from the reactor pool and hot cells that may be radiologically contaminated	100 T
Equipment	Solid	A	Facility equipment that may be radiologically contaminated, particularly equipment in the Reactor Facility and Hot Cell Facility	10 T
Contaminated soil, if any	Solid	A	Contaminated soil, if found, is processed as Class A waste	If needed

Abbreviations: yd^3 = cubic yard(s) | T = ton(s)

Table 19.2.7-3
Approximate Bounding Inventories of Nonradioactive Chemicals Associated with EIPC

Chemical	Approximate Bounding Inventory	Department of Transportation (DOT) Hazard Class (IAFC, 2022)
HNO_3 –15.8 M	725 L (192 gal.)	Class 8 – Corrosive Substances
0.5 M AHA in 0.1 M HNO_3	150 L (40 gal.)	N/A
TBP in n-dodecane	450 L (118 gal.)	N/A
Ca (s)	120 kg (54.4 lb.)	Class 4.3 – Substances Which in Contact with Water Emit Flammable Gases
H_2SO_4 –18.4 M	1 L (0.26 gal.)	Class 8 – Corrosive Substances
NaOH –19.4 M	100 L (26.4 gal.)	Class 8 – Corrosive Substances
ABO (s)	6 kg (13.2 lb.)	N/A
HCl –12.1 M	2 L (0.53 gal.)	Class 8 – Corrosive Substances
H_2O_2	0.5 L (0.13 gal.)	Class 5.1 – Oxidizing Substances
$KmnO_4$ (s)	300 g (10.6 oz.)	Class 5.1 – Oxidizing Substances
$RhCl_3H_6O_3$ (s)	600 g (21.2 oz.)	Class 8 – Corrosive Substances
K_3RuCl_6 (s)	850 g (30 oz.)	N/A
$AgNO_3$ (s)	1.5 kg (3.3 lb.)	Class 5.1 – Oxidizing Substances
NaI (s)	200 g (7.1 oz.)	N/A
O_2 (g)	33,000 L (8718 gal.)	Class 2.2 – Non-flammable, non-toxic gases
Argon (l)	3790 L (1000 gal.)	Class 2.2 – Non-flammable, non-toxic gases
Diesel fuel (generators)	30,300 L (8000 gal.)	Class 3 – Flammable Liquids (and Combustible Liquids)
Diesel fuel (fire pump)	833 L (220 gal.)	Class 3 – Flammable Liquids (and Combustible Liquids)

Abbreviations: DOT = U.S. Department of Transportation | HNO_3 = nitric acid | M = molarity | L = liter(s) | gal. = gallon(s) | AHA = acetohydroxamic acid | N/A = not applicable | TBP = tributyl phosphate | Ca = calcium | s = solid | kg = kilogram(s) | lb. = pound(s) | H_2SO_4 = sulfuric acid | NaOH = sodium hydroxide | ABO = alpha benzoin oxime | HCl = hydrochloric acid | H_2O_2 = hydrogen peroxide | $KMnO_4$ = potassium permanganate | g = gram(s) | oz. = ounce(s) | $RhCl_3H_6O_3$ = rhodium chloride trihydrate | K_3RuCl_6 = potassium hexachlororuthenate | $AgNO_3$ = silver nitrate | NaI = sodium iodide | O_2 = oxygen

Table 19.2.7-4
Types of Nonradioactive Hazardous Materials During Construction

Material	Description
Petroleum products	Most construction vehicles are powered by petroleum hydrocarbons and contain oil and hydraulic fluids during operation.
Compressed gases	High-pressure gas cylinders, including oxygen, acetylene, nitrogen, carbon dioxide, and argon may be used.
Wood treatments	Various treatments, which may include copper compounds, creosote, or arsenic, are applied to wood to preserve it.
Halogenated flame retardants	Flame retardants are chemicals incorporated in construction materials during manufacturing to slow or stop the spread of flames by forming a protective film or inhibiting chemical reactions that support combustion in case of a fire. When heated, these retardants degrade into toxic substances in a gaseous form, which then mixes with dust.
Volatile organic compounds	Solvents, paints, adhesives, and primers often contain VOCs as well as semi-volatile compounds.
Steel alloys	Specialty steel alloys and the associated welding processes may contain chromium, nickel, and zinc. These metals may be liberated during the welding or grinding processes.
Silica	Silica is a naturally occurring substance found in stone, sand, concrete, tiles, and bricks. Silica dust is inevitable on a construction site.
Fiberglass and other mineral fiber	These fibers are generally made from glass, ceramic, rock wool, and slag wool and are usually used for temperature and sound insulation.

Abbreviations: VOC = volatile organic compound

19.2.8 STORAGE, TREATMENT, AND TRANSPORT OF RADIOACTIVE AND NONRADIOACTIVE MATERIALS, INCLUDING FUEL, WASTE, RADIOISOTOPES, AND OTHER MATERIALS

19.2.8.1 Summary

The radioactive materials used during construction, as identified in Subsection 19.2.7.5, are not licensed to Eden and are handled in accordance with standard procedures for this type of radioactive equipment.

The nonradioactive hazardous materials used during construction, as identified in Subsection 19.2.7.5.2.1, are cleaned up in accordance with spill prevention and remediation practices. These materials are collected, stored, and recycled or recovered at an off-site permitted recycling or recovery facility as appropriate.

During operations, radioactive and contaminated wastes generated in solid form are sent to disposal in 55-gal. (208-L) drums, with the exception of: (1) equipment that does not readily fit in drums, including HEPA/HEGA filters; and (2) miscellaneous wastes, such as PPE. Large equipment, HEPA/HEGA filters, and miscellaneous wastes, such as PPE are packaged in box-shaped containers. The drums and containers are temporarily stored on-site and shipped in containers appropriate to the class of waste. Waste from the HCF target processing canyon is not greater than Class C, but in some instances, may be lower (e.g., lower concentration of waste in a drum, stored on-site longer). Other radioactive waste is disposed of as Class A.

Nonradioactive hazardous materials for the processing of Mo-99 and other process operations are stored in the PWH and are then assembled into a kit either there or in the POC laboratory space for transfer into the HCF target processing canyon hot cells or gloveboxes, as needed. Storage of these chemicals complies with the requirements of a chemical management plan that includes:

- Segregation of incompatible chemicals.
- Flammable chemicals that are stored in a flammable storage cabinet.
- Oxidizers that are segregated from flammable chemicals and reducers.

During decommissioning, radioactive waste is placed in containers appropriate for the form and radioactivity in the waste. For example, large components that do not fit in a 55-gal. (208-L) drum may be packaged in an appropriate box. It is anticipated that waste from decommissioning activities is Class A.

It is the intent to dispose of waste soon after it is generated in order to maintain a low on-site radioactive waste inventory; however, to allow it to decay to levels for facility handling, to meet Class C limits, and to meet transportation and receiver schedules, radioactive process waste is typically stored on-site for a minimum of 12 months.

19.2.8.2 On-Site Storage Capacity

On-site storage capacity exists for unirradiated targets, fresh or reclaimed LEU as U_3O_8 or U metal, irradiated targets, and radioisotope products, as further described below.

19.2.8.2.1 Target or Reactor Fuel Materials

The EMIF has a fissile material storage area (SNM storage area) to store unirradiated targets, U_3O_8 powder, and U metal ingots. Similarly, U metal foils are stored in the secured SNM storage area in a criticality safe condition. The materials are in any of these four combinations in the SNM storage area. The listed forms are segregated and maintained in custom-designed, criticality safe containers, drawers, and racks for both dry and flooded conditions. Minimal moderator materials are used in the SNM storage area and designed into the containers, drawers, and racks.

19.2.8.2.2 Irradiated Targets

Irradiated targets are transferred directly from the reactor pool to the HCF target receipt box via an underwater transfer canal in an irradiated target transfer basket. From the target receipt box, the irradiated targets are then transferred to a dissolver box in the hot cell line by the HCF box-to-box material transfer systems that run down the center of the HCF with dissolver boxes, purification boxes, research and development boxes, UREX boxes, and packaging boxes. This is accomplished in as short a time as possible to minimize decay of the Mo-99 product.

19.2.8.2.3 Radioisotope Products

The Mo-99 product is packaged for shipping off-site in a Type B container in the packaging box in the hot cell line. Other potential products are packaged in Type A or Type B containers depending on the specific radionuclide and quantities to be shipped. These containers are then transferred out of the hot cell and transported to the shipping dock.

19.2.8.3 Treatment and Packaging

19.2.8.3.1 Treatment and Packaging of Nonradioactive Waste

Eden procedures control treatment and packaging of nonradioactive wastes.

19.2.8.3.2 Treatment and Packaging of Radioactive Waste

During operations within the HCF, the radioactive waste is processed such that no spent fuel, high-level waste, or waste greater than Class C is generated. Within the HCF, the irradiated target cladding is removed in the dissolver box and the target cladding is sent to the waste packaging SCB for direct placement into a process canyon waste drum. The target is then dissolved in the dissolver box. The dissolver, when ready for replacement, is also sent to the waste packaging SCB for direct placement into a process canyon waste drum. The Mo-99 is then recovered from the dissolved target and purified in the purification box, followed by U recovery in the UREX process in the UREX box. Other process wastes generated during purification and UREX box operations are glassware and TiO_2 columns that are transferred to the waste packaging box for direct placement into a process canyon waste drum. The raffinate from the UREX process contains >99.9 percent of other fission products. This liquid raffinate is sent to the waste packaging box for solidification with a dry grout mix in a process canyon waste drum along with target cladding, dissolvers, glassware, and TiO_2 columns that are used in the hot cell processes. There is adequate storage space in the waste storage canyon for approximately 1 to 4 years of waste inventory (depending on production schedules) and it is intended for the process canyon waste drums to be disposed of after approximately one year.

During operations and decommissioning, miscellaneous LLW (e.g., PPE, glassware, hardware) that is not recoverable is compacted, when practical, and stored in appropriate containers for disposal.

19.2.8.3.3 Treatment and Packaging of Radioisotope Products

Purified Mo-99 is transferred to the product packaging box in the HCF target processing canyon.

The shippable container is packed within the inner shield of the U.S. Department of Transportation- (DOT) and NRC-compliant shipping container. The packaged product is removed from the product packaging box utilizing a shielded airlock system. The shield container with product is then placed within the DOT- and NRC-compliant overpack to meet regulatory requirements for shipment, placarded, and shipped.

19.2.8.4 Transportation Packaging

Transportation packaging for off-site shipment is per DOT and NRC requirements. Product shipments of Mo-99, I-131, Xe-133, and other product materials are packaged in DOT- and NRC- approved shipping containers. NRC regulations for the required packaging are contained in 10 CFR Part 71 and DOT regulations in 49 CFR Part 173. Miscellaneous LLW is in Type A containers, and process waste (Class C) is in Type B containers. The RT-100 USA/9365/B(U)-96 and 10-160B USA/9204/B(U)-96 are compliant Type B containers that can each hold up to ten 55-gal. (208-L) drums.

For the Mo-99 product, the MIDUS cask USA/9320/B(U)-96 is a Type B container that is used.

Fresh LEU is shipped from the DOE Y-12 program office in Oak Ridge, Tennessee (TN), to the EMIF using a DOT- and NRC-compliant Type B container.

Targets are fabricated on-site from either fresh LEU or from recovery of U following recovery of Mo-99. If targets are not fabricated on-site, they are also shipped to the site in DOT- and NRC-compliant Type B containers. For both fresh LEU and targets, the ES-3100 (USA/9315/B(U)-96) shipping container is a Type B container that is expected to be used.

Targets are processed on-site into either a product or process waste, which is transported off-site as discussed above. U is recovered and processed back to U metal for fabrication of new targets on-site. As the U is depleted, it may be shipped back off-site or disposed of along with waste from the HCF target processing canyon.

19.2.8.5 Transportation Distances

19.2.8.5.1 Transportation Distances for the Enriched Uranium

The enriched U for the fuel targets fabricated at the EMIF is obtained from the DOE Y-12 facility in Oak Ridge, TN. It is transported from the DOE Y-12 facility by truck. The distance from this facility to the EMIF is approximately 1200 mi. (1800 km) by road.

If targets are fabricated off-site, the enriched U is sent to an off-site vendor to fabricate the targets from the enriched U supplied from the DOE Y-12 facility. This may add additional distance for the fuel source for the EMIF but is not expected to add significant transportation distance, as the

vendor is domestically sourced. For the purpose of the ER, it is assumed that total transportation for the fuel source with off-site target fabrication is approximately 1500 mi. (2400 km).

19.2.8.5.2 Transportation Distances for the Medical Isotopes

The medical isotopes produced at the EMIF are transported by truck to airports in New Mexico and Texas where they are transported by air to various facilities for generator loading and distribution to medical facilities. Three to five product delivery trips via air travel are made weekly. Highway distances from the site to airports that are used for product delivery are:

- Lea County Regional Airport (Hobbs, NM): approximately 26 mi. (42 km) from the EIPC.
- Roswell Air Center (Roswell, NM): approximately 128 mi. (206 km) from the EIPC.
- Cavern City Air Terminal (Carslbad, NM): approximately 78 mi. (126 km) from the EIPC.
- Albuquerque International Sunport (Albuquerque, NM): approximately 341 mi. (549 km) from the EIPC.
- Lubbock Preston Smith International Airport (Lubbock, TX): approximately 134 mi. (216 km) from the EIPC.
- Rick Husband Amarillo International Airport (Amarillo, TX): approximately 255 mi. (410 km) from the EIPC.
- Midland International Air and Space Port (Midland, TX): approximately 72 mi. (116 km) from the EIPC.

Although economically undesirable, transportation by truck is used as a backup in cases where inclement weather does not permit air delivery. Highway distances from Eunice, NM, to potential recipient facilities are:

- Mallinckrodt Pharmaceuticals facility (Hazelwood, Missouri): approximately 970 mi. (1550 km).
- Lantheus Medical Imaging facility (North Billerica, Massachusetts): approximately 2150 mi. (3450 km).

19.2.8.5.3 Transportation Distances for Waste

Radioactive waste from operations and decommissioning is transported by truck to the WCS disposal facility in nearby Andrews, TX. The highway distance from the EIPC to the disposal facility is about 2 mi. (3.2 km), with approximately 40 radioactive waste delivery trips per year made. Other alternative optional disposal sites include:

- U.S. Ecology Washington Energy Solutions facility (Richland, Washington): approximately 1600 mi. (2600 km) from the EIPC by road.
- Diversified Scientific Services, Inc. facility (Kingston, TN): approximately 1200 mi. (2000 km) from the EIPC by road.

Nonradioactive waste from operations and decommissioning is transported by truck to the Lea County Landfill, about 1.5 mi. (2.5 km) by road.

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Figure 19.2.1-1
Map of the 8 Kilometer Area Surrounding the Eden Isotope Production Complex

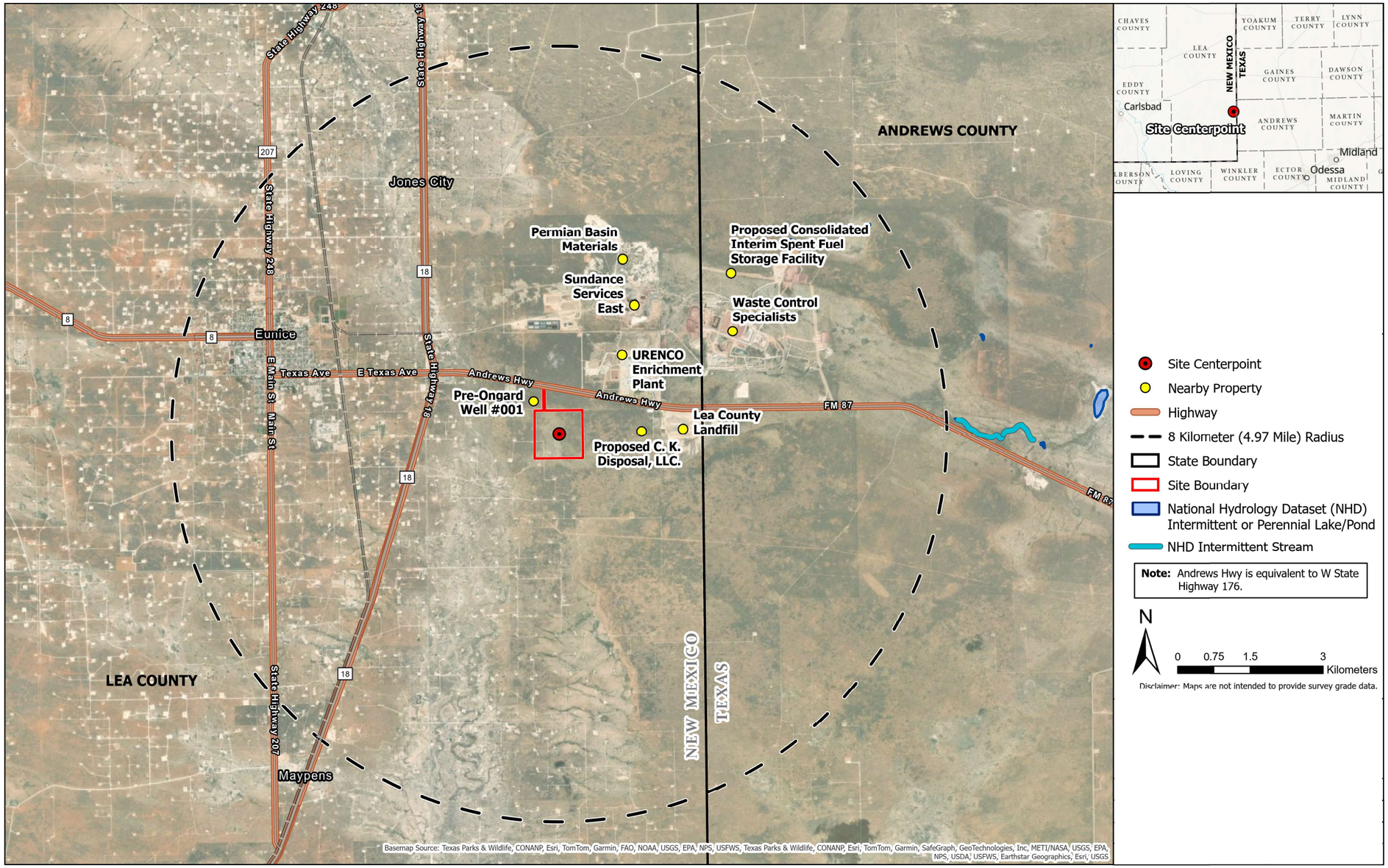


Figure 19.2.1-2
Map of the 200 Kilometer Area Surrounding the Eden Isotope Production Complex

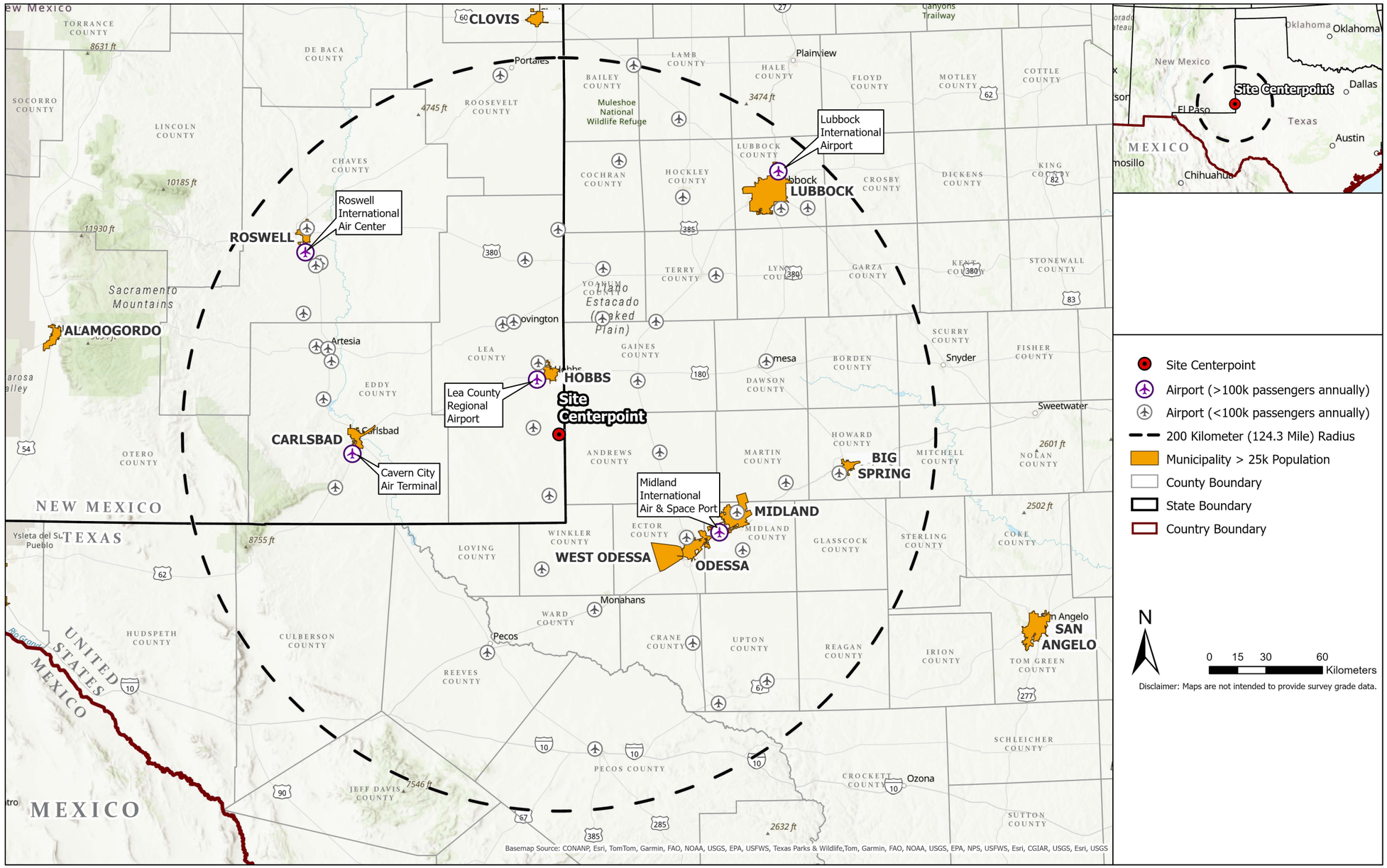


Figure 19.2.1-3
Map of the Eden Isotope Production Complex Off-Site Utility Corridor

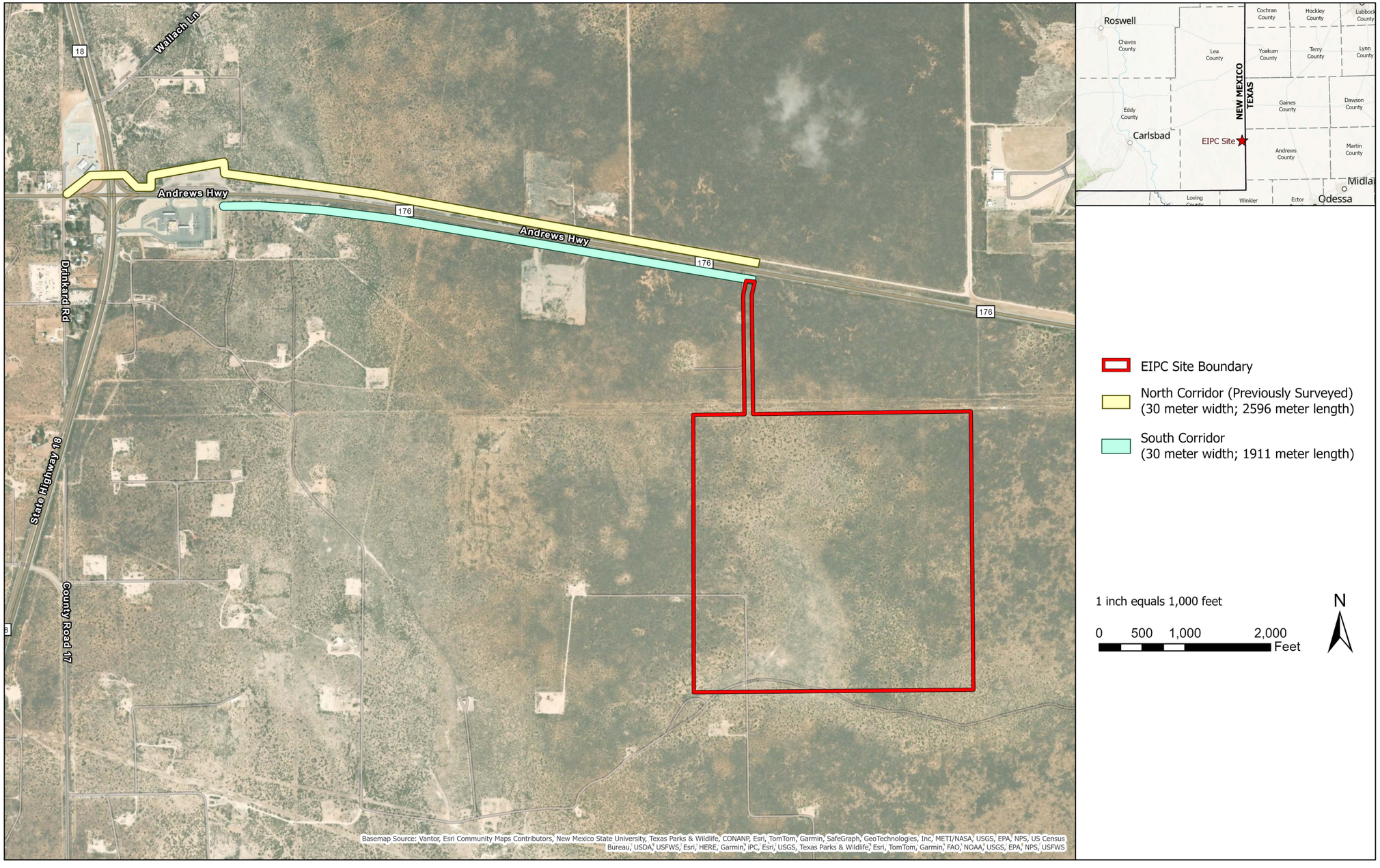
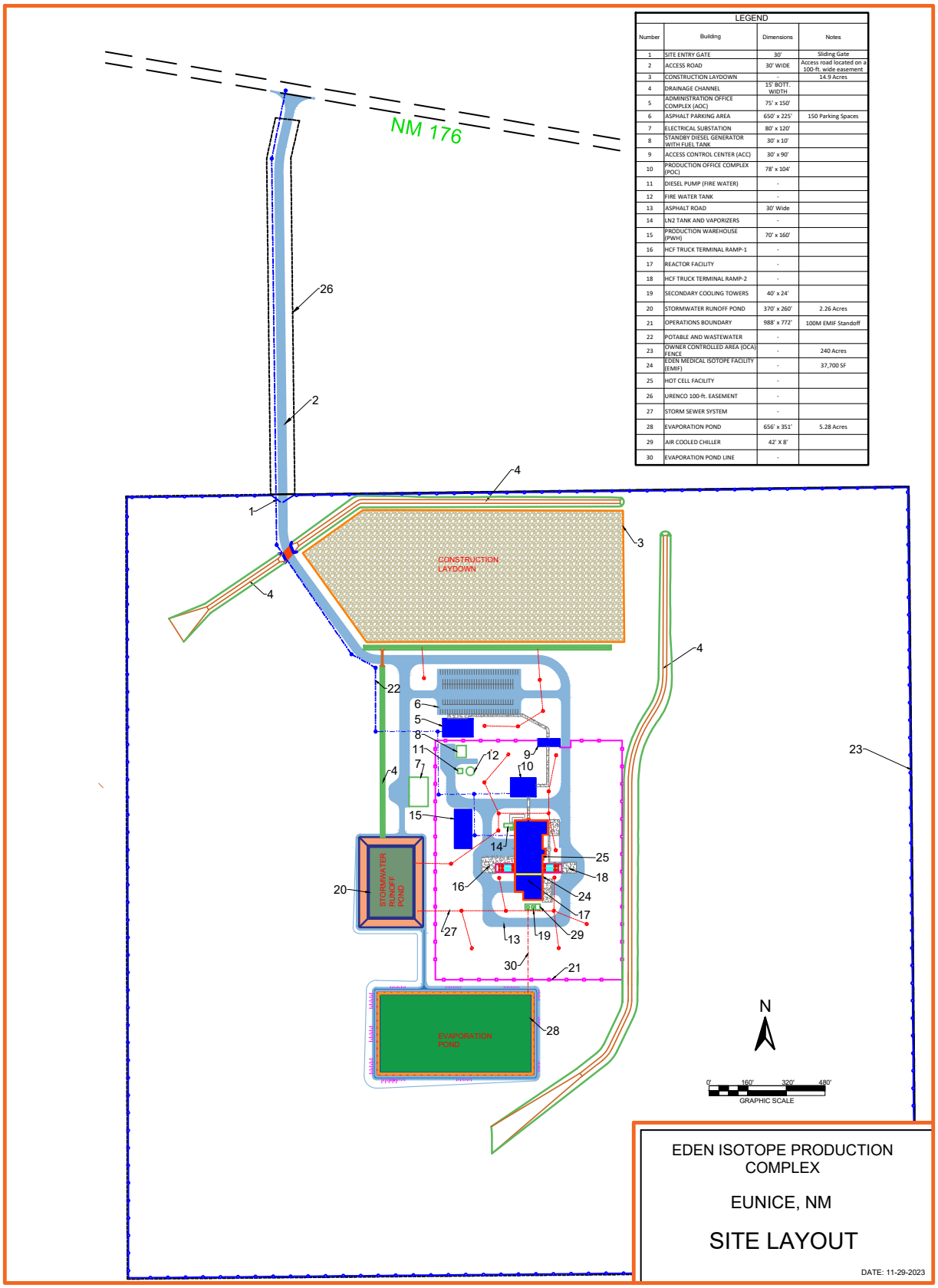


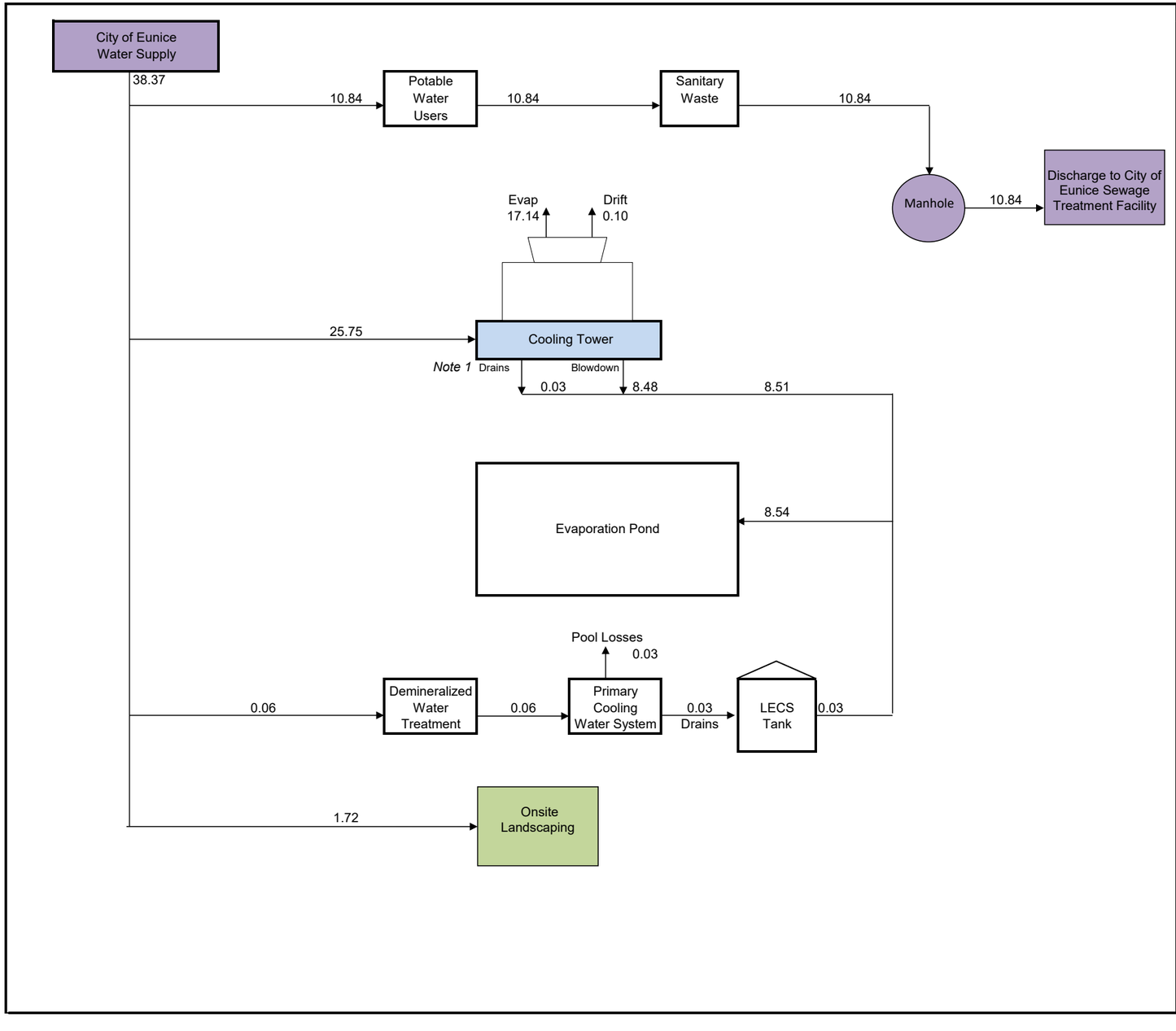
Figure 19.2.1-4
Eden Isotope Production Complex Site Layout



LEGEND

Number	Building	Dimensions	Notes
1	SITE ENTRY GATE	30'	Sliding Gate
2	ACCESS ROAD	30' WIDE	Access road located on a 100-ft. wide easement
3	CONSTRUCTION LAYDOWN		14.9 Acres
4	DRAINAGE CHANNEL	15' BOTT. WIDTH	
5	ADMINISTRATION OFFICE COMPLEX (ADC)	75' x 150'	
6	ASPHALT PARKING AREA	650' x 225'	150 Parking Spaces
7	ELECTRICAL SUBSTATION	80' x 120'	
8	STANDBY DIESEL GENERATOR WITH FUEL TANK	30' x 10'	
9	ACCESS CONTROL CENTER (ACC)	30' x 90'	
10	PRODUCTION OFFICE COMPLEX (POC)	78' x 104'	
11	DIESEL PUMP (FIRE WATER)	-	
12	FIRE WATER TANK	-	
13	ASPHALT ROAD	30' Wide	
14	LN2 TANK AND VAPORIZERS	-	
15	PRODUCTION WAREHOUSE (PWH)	70' x 160'	
16	HCF TRUCK TERMINAL RAMP-1	-	
17	REACTOR FACILITY	-	
18	HCF TRUCK TERMINAL RAMP-2	-	
19	SECONDARY COOLING TOWERS	40' x 24'	
20	STORMWATER RUNOFF POND	370' x 260'	2.26 Acres
21	OPERATIONS BOUNDARY	988' x 772'	100M EMIF Standoff
22	POTABLE AND WASTEWATER	-	
23	OWNER CONTROLLED AREA (OCA) FENCE	-	240 Acres
24	EDEN MEDICAL ISOTOPE FACILITY (EMIF)	-	37,700 SF
25	HOT CELL FACILITY	-	
26	URENCO 100-ft. EASEMENT	-	
27	STORM SEWER SYSTEM	-	
28	EVAPORATION POND	656' x 351'	5.28 Acres
29	AIR COOLED CHILLER	42' X 8'	
30	EVAPORATION POND LINE	-	

Figure 19.2.3-1
Eden Isotope Production Complex Water Balance



Water Balance Notes and Assumptions

1. Cooling tower assumed to operate at 3.0 cycles of concentration.
2. A total design margin of 36.5%has been added to each flow for conservatism.

Figure 19.2.3-2
Reactor Facility High Bay Ventilation System

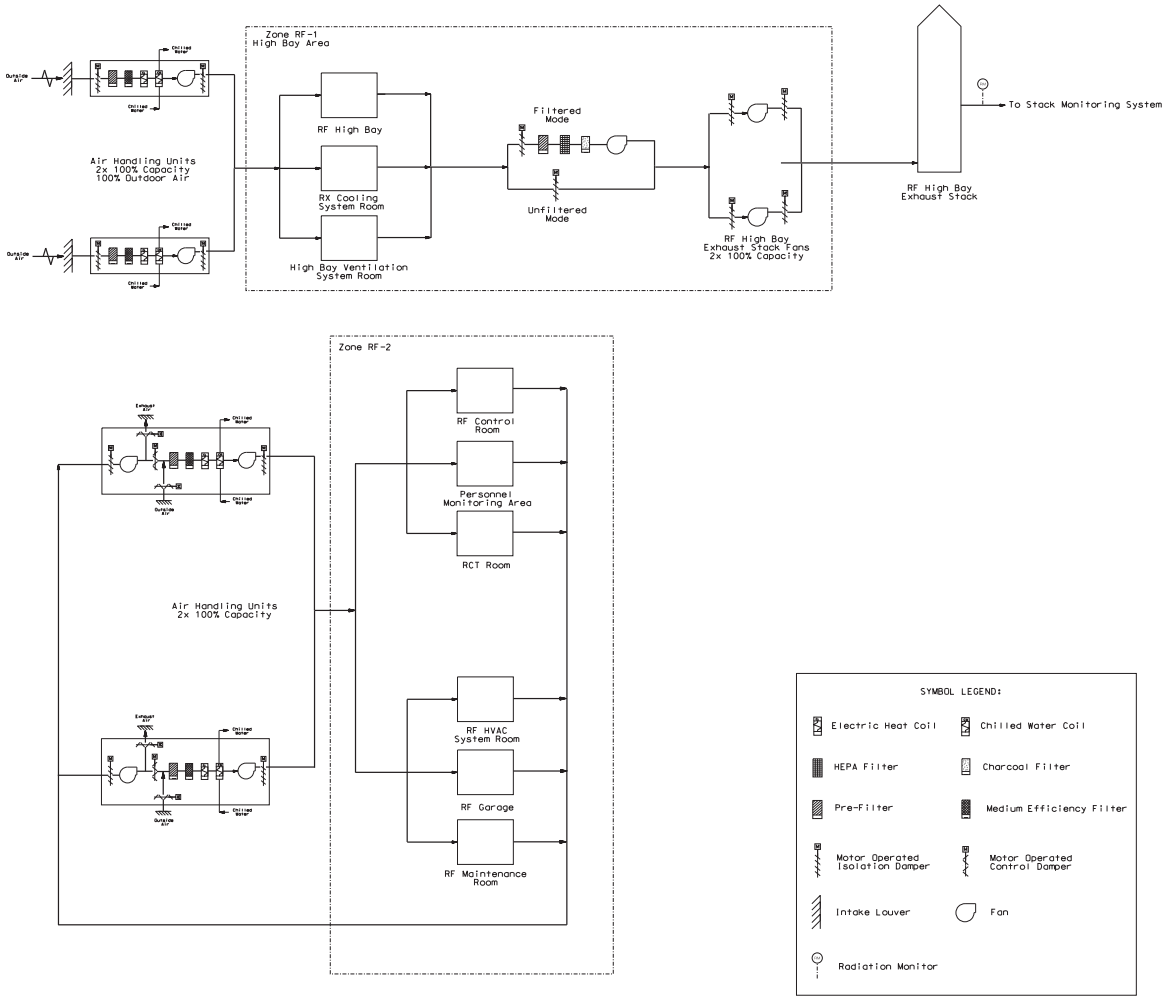
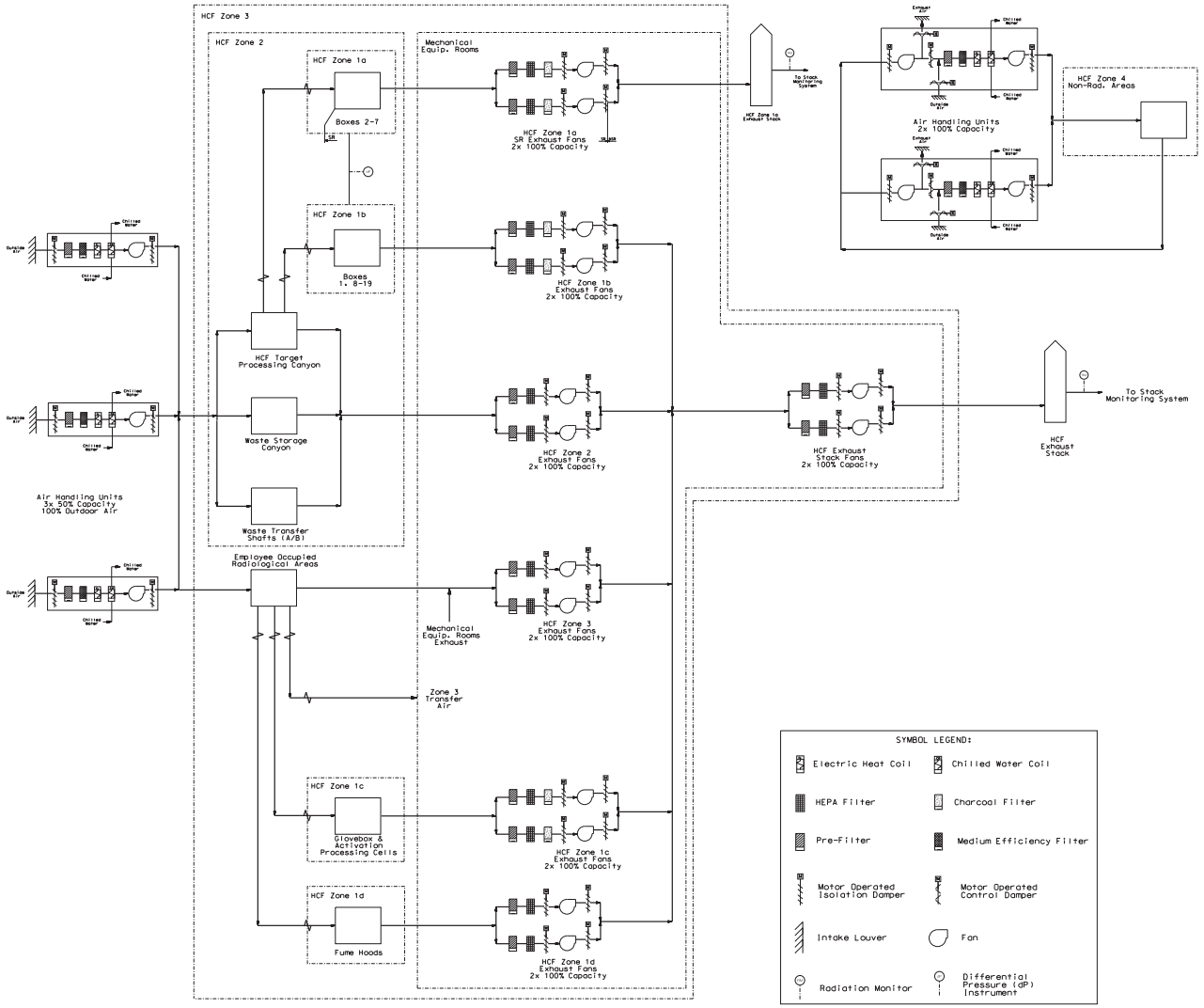


Figure 19.2.4-1
Hot Cell Facility Ventilation System



Eden Isotope Production Complex
Preliminary Safety Analysis Report

March 2026
Revision 0

Chapter 19
Environmental Report

Section 19.3
Description of Affected Environment

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CHAPTER 19
ENVIRONMENTAL REPORT

SECTION 19.3 DESCRIPTION OF AFFECTED ENVIRONMENT

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
µg	micrograms
µm	micrometer(s)
µmhos	micromho(s)
µS	microsiemen(s)
ac.	acre(s)
ac-ft	acre-feet
ACS	American Community Survey
AMSL	above mean sea level
APE	area of potential effect
ARMS	New Mexico Archaeological Records Management System
ASCE/SEI	American Society of Civil Engineers/Structural Engineering Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
BLM	U.S. Bureau of Land Management
BLS	U.S. Bureau of Labor Statistics
C-14	Carbon-14
CBG	census block group
CFR	Code of Federal Regulations
CHAT	crucial habitat assessment tool
CISF	consolidated interim storage facility

Acronym/Abbreviation	Definition
C.K. Disposal	C.K. Disposal, LLC, Surface Waste Management Facility
cm	centimeter(s)
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COOP	cooperative observing program
CT	computerized tomography
CWF	Compact Waste Disposal Facility
dB	decibel(s)
dBA	A-weighted decibel(s)
DBT	dry bulb temperature
DOI	U.S Department of the Interior
DRS	Design Response Spectrum
ECHO	Enforcement and Compliance History Online
Eden	Eden Radioisotopes, LLC
EF scale	enhanced Fujita tornado intensity scale
EIPC	Eden Isotope Production Complex
EIS	environmental impact statement
EMIF	Eden Medical Isotope Facility
EPRI	Electric Power Research Institute
F scale	Fujita tornado intensity scale
FAA	Federal Aviation Administration
ft.	foot/feet
FTE	full-time equivalent (employee)

Acronym/Abbreviation	Definition
FWF	Federal Waste Disposal Facility
g	acceleration due to gravity
gal.	gallon(s)
GAP	Gap Analysis Project
GCD	Groundwater Conservation District
GHG	greenhouse gas
GMU	game management unit
gpd	gallons per day
GT	gigaton
H_2S	hydrogen sulfide
H_2SO_4	sulfuric acid
ha	hectare(s)
ha-m	hectare-meter(s)
HAP	hazardous air pollutant
HHE	Health Hazard Evaluation
hr.	hour(s)
HUC	Hydrologic Unit Code
IIFP	International Isotopes Fluorine Products, Inc.
in.	inch(es)
ISD	independent school district
ISP	Interim Storage Partners, LLC
K-40	potassium-40
kg/m^2	kilogram(s) per square meter
KHOB	Lea County Regional Airport
km	kilometer(s)

Acronym/Abbreviation	Definition
km^2	square kilometer(s)
L	liter(s)
lb/ft^2	pounds per square foot
LCD	local climatological data
L_{dn}	day–night average noise level
LLW	low-level (radioactive) waste
LU/LC	land use/land cover
m	meter(s)
m/s	meters per second
m^2	square meter(s)
m^3	cubic meter(s)
mb	body wave magnitude
MEI	maximally exposed individual
mg	milligram(s)
mi.	mile(s)
mi^2	square mile(s)
mill	millage
mmhos	millimho(s)
mph	mile(s) per hour
mrem	millirem
mSv	millisievert(s)
NAAQS	National Ambient Air Quality Standards
NAVD 88	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information (formerly known as the National Climatic Data Center [NCDC])

Acronym/Abbreviation	Definition
NCRP	National Council on Radiation Protection
NHD	National Hydrography Dataset
NIOSH	National Institute for Occupational Safety and Health
NLCD	National Land Cover Database
NM	New Mexico
NM-18	New Mexico Highway 18
NM-176	New Mexico Highway 176
NM-207	New Mexico Highway 207
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NMSA	New Mexico Statutes Annotated
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity units
NWI	National Wetland Inventory
NWS	National Weather Service
O_3	ozone
Pb	lead
pCi	picocurie(s)
PM	particulate matter

Acronym/Abbreviation	Definition
PM_{10}	particulate matter with an aerodynamic diameter less than 10 µm
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 µm
ppm	parts per million
Ra	radium
REMP	Radiological Environmental Monitoring Program
RF	Reactor Facility
Rn	radon
ROI	region of influence (socioeconomic)
RV	recreational vehicle
sec.	second(s)
SGCN	species of greatest conservation need
SHPO	New Mexico State Historic Preservation Office
SO_2	sulfur dioxide
SWAP	State Wildlife Action Plan
SWReGAP	Southwest Regional Gap Analysis Project
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent detector
TPWD	Texas Parks & Wildlife Department
TRI	Toxics Release Inventory
TRS	total reduced sulfur
TX	Texas
U	uranium

Acronym/Abbreviation	Definition
UHRS	Uniform Hazard Response Spectra
URENCO	Urenco USA
USCB	U.S. Census Bureau
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWB	underground water basin
VOC	volatile organic compound
WBT	wet bulb temperature
WCS	Waste Control Specialists, LLC
yr.	year(s)

19 Environmental Report

19.3 DESCRIPTION OF AFFECTED ENVIRONMENT

This section of the Environmental Report describes the regional and local environmental characteristics at the proposed 245.6-acre (ac.) (99.4-hectare [ha]) Eden Isotope Production Complex (EIPC) project area (including the property owned by Eden Radioisotopes, LLC [Eden] and easement). The information includes data on existing conditions at the project site and addresses the following environmental topics:

- Land use and visual resources
- Air quality and noise
- Geologic environment.
- Water resources
- Ecological resources
- Historic and cultural resources
- Socioeconomics
- Human health

Documents associated with license applications for two nearby sites, the Urenco USA (URENCO) uranium enrichment facility and the proposed consolidated interim storage facility (CISF) at the Waste Control Specialists (WCS) site, were used in preparation of this section. The NRC prepared environmental impact statements (EISs) in support of the URENCO license application (NUREG-1790, Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, NM) and the CISF license application (NUREG-2239, Environmental Impact Statement for Interim Storage Partners LLC's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Andrews County, TX). Due to the proximity to the EIPC, portions of these EISs, as well as the environmental report prepared by Interim Storage Partners (ISP) for the proposed CISF (ISP, 2020) are used herein with the corresponding reference noted where appropriate.

19.3.1 LAND USE AND VISUAL RESOURCES

This section describes land use and visual resources of the EIPC project site and region. Land use for the project site and region is analyzed using the U.S. Geological Survey (USGS) National Land Cover Database (NLCD) land use/land cover (LU/LC) information (Dewitz, 2021). Visual resources are rated using the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM) Visual Resource Management program (BLM, 1984).

19.3.1.1 Land Use

19.3.1.1.1 Project Site

The project area consists of 245.6 ac. (99.4 ha) comprised of Eden property and an easement in Lea County, New Mexico (NM). Given the undeveloped nature of the project site, no existing structures or infrastructure are within the project site boundary. Historically, the site has been used for cattle grazing, per a Phase I Environmental Site Assessment (prepared by NV5 in 2020). Figure 19.3.1-1 illustrates the project site boundary and site center point. The EIPC and associated facilities on the developed project site are described in Section 19.2.

According to the USGS NLCD, LU/LC within the project site consists almost entirely of scrub/shrub land with a small amount of developed, low-intensity land use (Figure 19.3.1-2). Table 19.3.1-1 details the acreage and percent coverage of LU/LC categories within the project site and region, and LU/LC is illustrated on Figure 19.3.1-2 (Dewitz, 2021). Approximately 99 percent of the project site is designated by the Natural Resources Conservation Service (NRCS) as prime farmland of statewide importance (Table 19.3.1-2). The soils associated with prime farmland at the project site are mapped as Brownfield-Springer association and Gomez loamy fine sand (0 – 3 percent slopes). The remaining 1 percent of the project site is classified as “not prime” farmland and is mapped as Kermit soils and Dune land (0 – 12 percent slopes) (NRCS, 2022).

In addition to the project site, an off-site utility corridor spans the north and south sides of New Mexico Highway 176 (NM-176) west of the project site and terminates just west of New Mexico Highway 18 (NM-18) (Figure 19.3.1-1). This utility corridor bounds the location where utilities are to be sited. As described in Section 19.2.1, utilities are anticipated to be sited in the corridor on the north side of NM-176. The USGS NLCD LU/LC within the off-site utility corridor generally consists of scrub/shrub and developed land. Soils within the off-site utility corridor consist of some farmland of statewide importance and some soils that are not mapped as prime farmland.

Additional details regarding the specific soil types and associated characteristics are described in Section 19.3.3.

19.3.1.1.2 Region

The 5-mile (mi.) (8-kilometer [km]) radius around the project site center point is defined as the region. The region spans Lea County, NM, and Andrews County, Texas (TX). LU/LC for the region is defined in Table 19.3.1-1 and illustrated on Figure 19.3.1-2. The dominant land use in the region is scrub/shrub, accounting for 92 percent of the area. Approximately 6.5 percent of the region is defined as developed, high-intensity, and multiple industrial and developed facilities are located within the region (Dewitz, 2021). The locations of industrial and developed facilities within the region are shown in Figure 19.3.1-3.

The URENCO uranium (U) enrichment facility is an international supplier of enrichment services and fuel-cycle products for the civil nuclear industry, which produces low-carbon electricity (URENCO, 2022a). The URENCO U enrichment facility is located approximately 1.3 mi. (2.1 km) northeast of the project site and is the only U enrichment plant currently operating in the United States. Construction of the plant began in 2006, and the plant's first enrichment cascade reached full production in June 2010 (URENCO, 2022a). URENCO's advanced gas centrifuge enrichment technology can produce all levels of U enrichment, and the facility employs more than 230 people (URENCO, 2022a, 2022b). Its current capacity is 4600 tons of separative work units per year (URENCO, 2022b).

The WCS facility is a 1338-ac. (541-ha) nuclear facility (WCS Texas, 2022a) in Andrews County, TX, approximately 2.6 mi. (4.2 km) to the east of the project site. WCS is licensed to treat, store, and dispose of Class A, B, and C low-level radioactive waste (LLW) as well as low-activity waste, hazardous waste, and byproduct materials. WCS has served as a long-term storage facility for nuclear power plants, industrial facilities, hospitals, research centers, and the U.S. Department of Energy (WCS Texas, 2022a). The WCS facility maintains capacity for 37,500 cubic feet (1062 m^3) of container storage and 17,118 cubic feet (485 m^3) of bin storage (WCS Texas, 2022b). The WCS facility employs approximately 100 people (WCS Texas, 2022a).

The Lea County, NM, landfill is located approximately 1.6 mi. (2.6 km) to the east of the project site. The landfill is a municipal solid waste landfill operating under a permit issued by the State of New Mexico for the disposal of municipal solid waste (Lea County Landfill, 2022). The Lea County landfill occupies approximately 340 ac. (137 ha) with an estimated life of 80 years (Lea County, 2022a). The landfill has its own hauling company and is a full-service solid waste disposal company for normal household garbage, non-hazardous commercial waste, farm or agricultural waste, municipal solid waste, construction debris, concrete and asphalt, yard waste, tree branches, dry waste, clean fill (such as soil), non-hazardous industrial waste, wastewater treatment plant sludge, industrial sludges, industrial powders, contaminated soil (non-radioactive), and treated lumber (Lea County Landfill, 2022).

The proposed C.K. Disposal, LLC (C.K. Disposal) Surface Waste Management Facility for oilfield waste processing and disposal services would be located within the region. The proposed C.K. Disposal site occupies approximately 317 ac. (128 ha) and is 4.2 mi. (6.8 km) east of Eunice and 0.5 mi. (0.8 km) west of the New Mexico–Texas border (C.K. Disposal, LLC, 2015). Permian Basin Materials, a sand and gravel quarry, is located 2.4 mi. (3.9 km) north of the project site. The facility contains a large spoil pile and three industrial "produced water" lagoons, water produced as a byproduct of oil and gas production. Sundance Services, a full-service oilfield waste disposal facility, is located 1.9 mi. (3.0 km) north of the project site.

19.3.1.1.2.1 Special Land Uses

No special land-use classifications, such as American Indian or military reservations, Bureau of Indian Affairs lands held in trust for American Indians, wild and scenic rivers, national parks, national forests, designated coastal zone areas, federal wildlife refuges, and wilderness areas, are located within the region; however, the region does contain "National Public Lands" managed by the Carlsbad Field Office of the BLM National Public Lands. These lands are subject to extractive (e.g., mining or logging) or off-highway vehicle uses, and NRCS prime farmland soils of statewide importance are present in the region. Additionally, the off-site utility corridor traverses through areas designated as New Mexico State Trust Land (Figure 19.3.1-1 and Subsection 19.3.5.4).

19.3.1.1.2.2 Agricultural Resources and Facilities

Approximately 23 percent (11,678.6 ac. [4726.2 ha]) of the region is considered prime farmland of statewide importance (Table 19.3.1-2). The main soils associated with prime farmland in the region are Brownfield-Springer association and Ratliff-Wink fine sandy loams. The remaining 77 percent of the land area in the region is not considered prime farmland (NRCS, 2022). The principal agricultural products in the region are livestock, which accounts for 83 percent and 52 percent of the share of agricultural sales by type in Lea County, NM, and Andrews County, TX, respectively (Table 19.3.1-3). More than 90 percent of active farmland is used for pastureland in both Lea County, NM, and Andrews County, TX. The main livestock in both counties is cattle and calves. The main crop in both counties is cotton followed by forage in Lea County, NM, and peanuts in Andrews County, TX (USDA, 2017).

19.3.1.1.2.3 Mineral Resources

The project site and region are located within the High Plains Level IV Ecoregion. The region is characterized by smooth to slightly irregular plains with high levels of cropland. This ecoregion includes the Llano Estacado plains and thousands of playa lakes, which are seasonal depressional wetlands. Oil and gas production occurs in this ecoregion (USEPA, 2006). Numerous mines are present within the region, and one active mine listed under the USGS Mineral Resources Data System is located near the URENCO facility. This mine, operated by Wallach Concrete, Inc., produces nonmetallic construction materials, including gravel and sand (USGS, 2022a).

The New Mexico Energy, Minerals, and Natural Resource Department, Oil Conservation Division, reports 16,917 active wells within Lea County, NM. The largest operators in Lea County are Apache Corporation with 1753 wells, EOG Resources, Inc., with 1184 active wells, and ConocoPhillips Company with 1085 active wells. Approximately 75 percent of the active wells in Lea County, NM, are oil wells. The remaining well types include gas, injection, and saltwater disposal.

19.3.1.1.2.4 Major Population Centers and Infrastructure

As depicted on Figure 19.3.1-3, the only major population center within the region is Eunice, NM, located approximately 1.4 mi. (2.2 km) west of the project site and home to approximately 3000 residents (City of Eunice, 2022a). Major roadways in the region include NM-18, NM-176, and New Mexico Highway 207 (NM-207). NM-176 becomes Texas State Highway 176 at the New Mexico–Texas state line, continuing approximately 31 mi. (50 km) southeastward to Andrews, TX. NM-176 provides direct access to the project site and is a two-lane highway. Additional details regarding transportation can be found in Section 19.3.7. The Texas–New Mexico Railroad, owed by Permian Basin Railways, operates 104 mi. (167 km) of railroad that extends from Monahan, TX, to Loving, NM, and passes through Eunice, NM. The railroad primarily hauls oilfield chemicals and minerals, construction aggregates, industrial waste, and scrap (Iowa Pacific, 2022). No airports or major waterways are located within the region.

19.3.1.1.2.5 Present Land Use and Potential Land Use Plans

Current and future land use plans for the region are represented by the Lea County Comprehensive Plan (Lea County, 2022b). The plan defines the following land-use categories:

- Open water

- Low-intensity residential
- High-intensity residential
- Commercial/industrial/transportation
- Bare rock/sand/clay
- Quarries/strip mines/gravel pits
- Deciduous forest
- Evergreen forest
- Shrubland
- Orchards/vineyards/other
- Grasslands/herbaceous
- Pasture/hay
- Row crops
- Small crops
- Fallow
- Urban/recreational grasses
- Woody wetlands
- Emergent herbaceous wetlands

According to the Lea County Comprehensive Plan, the lands within the project site and surrounding region are listed as shrubland or grasslands/herbaceous. The plan states that Lea County has no zoning regulations and that the county possesses an abundance of land suitable for development (Lea County, 2022b).

19.3.1.2 Visual Resources

The visual resources and scenic quality of the existing project site are rated using the DOI-BLM Visual Resource Management program (BLM, 1984).

19.3.1.2.1 Visual Setting

The visual setting of the project site is represented by agricultural viewsheds to the north, south, and west that consist of relatively flat terrain dominated by scrub/shrub land. The off-site utility corridor consists of a similar visual setting of predominately scrub/shrub. The project site itself is flat, consisting of scrub/shrub land with no established structures. The viewshed to the east consists of both pastureland and the Lea County landfill, and to the northeast is the URENCO facility. Subsection 19.3.1.1.2 provides additional details on the facilities. The EIPC is described in Section 19.2 and is anticipated to be visible to motorists traveling along NM-176. The EIPC is not visible from the closest population center (Eunice, NM) due to distance.

19.3.1.2.2 Proposed Structure

The tallest proposed structure within the EIPC is the Eden Medical Isotope Facility (EMIF) building, which is designed to be two stories tall, while all other site buildings are only one story

tall. The EMIF building design is consistent in appearance with other light industrial facilities in the surrounding area. Based upon the relatively flat topography of the project site and region, the EIPC is likely visible from all directions. Section 19.2 provides more details on the EIPC.

19.3.1.2.3 Sensitive Viewsheds

The project site and off-site utility corridor is relatively flat to gently sloping, and no mountain ranges or significant bodies of water occur in the project region (see Section 19.3.4). Additionally, no parks, wilderness areas, or other recreational areas are located within the region (see Section 19.3.7). As the project site is located near the URENCO industrial site and other waste and disposal facilities (Lea County Landfill), it is unlikely that residents or visitors currently interact with the project site for scenic viewing.

19.3.1.2.4 Scenic Evaluation Criteria

The scenic quality classification is the rating of the visual appeal of the land designated for the site and is based on an evaluation of seven key factors:

- Landform
- Vegetation
- Water
- Color
- Adjacent scenery
- Scarcity
- Cultural modification

Under the DOI-BLM Visual Resource Management program, scenic quality is classified as “A,” “B,” or “C,” with “A” representing a high-quality visual classification and “C” a low-quality visual rating. The sensitivity level, a measurement of the public concern for scenic quality, is based on six different indicators of public concern:

- Types of users
- Amount of use
- Public interest
- Adjacent land uses
- Special areas
- Other factors

The sensitivity level of the public concern for scenic quality is rated on a scale of “High” (H), “Moderate” (M), or “Low” (L).

The project site has a “C” classification for low scenic quality based on the following characteristics:

- The project site lacks interesting landscape features.

- The project site has little vegetation diversity.
- Water is absent.
- Color variation is generally subtle with mute tones.
- Adjacent scenery has little influence on visual quality.
- The visual setting is common within the region.
- Cultural modifications add little variety to the area.

The project site has an “L” sensitivity rating based on the following characteristics:

- Low scenic values result from low sensitivity to changes in visual quality by the types of uses in the area.
- There are low levels of use by viewers.
- The public has low interest in changes to the visual quality of the project site.
- There is low sensitivity from adjacent land uses.
- Special natural and wilderness areas are absent.

Table 19.3.1-1
Land Cover/Land Use within the Project Area and Region

	EIPC Project Area		Region	
NLCD Class	**Acres**	**Percent[(a)]**	**Acres**	**Percent[(a)]**
Barren Land			480.8	1.0
Cultivated Crops			22.5	<0.1
Developed, High Intensity			147.0	0.3
Developed, Medium Intensity			743.7	1.5
Developed, Low Intensity	0.02	0.01	849.2	1.7
Developed, Open Spaces			1559.3	3.1
Herbaceous			145.6	0.3
Open Water			88.5	0.2
Scrub/Shrub	245.6	99.9	46,225.6	92.0
Woody Wetlands			2.7	<0.1
Total	**245.6**		**50,264.9**	

Source: Dewitz, 2021
a) Total may add up to more or less than 100 percent due to rounding.
Abbreviations: EIPC = Eden Isotope Production Complex | NLCD = National Land Cover Database

Table 19.3.1-2
Prime Farmland Classification within Project Area and Region

	EIPC Project Area		Region	
Prime Farmland Class	**Acres**	**Percent**	**Acres**	**Percent**
Not Prime Farmland	1.8	1	38,586.3	77
Farmland of Statewide Importance	243.8	99	11,678.6	23
Total	**245.6**		**50,264.9**	

Source: NRCS, 2022
Abbreviations: EIPC = Eden Isotope Production Complex

Table 19.3.1-3
Major Agricultural Products in the Region

	Lea County, NM	Andrews County, TX
Farm Type by Land Use (%)		
Cropland	6%	9%
Pastureland	94%	91%
Share of Sales by Type (%)		
Crops	17%	48%
Livestock, poultry, and products	83%	52%
Top Crops (ac.)		
Cotton, all	16,375	11,314
Forage, all	11,855	592
Corn for silage or greenchop	10,552	N/A[a]
Peanuts	3762	1520
Vegetables	3234	N/A
Wheat for grain	N/A	1500
Livestock Inventory		
Cattle and calves	96,690	11,405
Sheep and lambs	3027	334
Layers	1352	733
Horses and ponies	1847	347
Goats	685	458
Hogs and pigs	[b]	300

Source: USDA, 2017
a) N/A = not available.
b) Withheld to avoid disclosing data for individual operations.
Abbreviations: NM = New Mexico | TX = Texas | ac. = acre(s)

19.3.2 AIR QUALITY AND NOISE

This section describes the regional climate, ambient air quality, and characteristics of noise sources and receptors near the EIPC.

19.3.2.1 Air Quality

19.3.2.1.1 General Climate

As described in Section 19.2.2, the EIPC is in eastern Lea County, NM, near the Texas–New Mexico border. The complex is located approximately 1.3 mi. (2.1 km) southwest of the URENCO U enrichment facility and 2.6 mi. (4.2 km) southwest of the WCS site, a radioactive waste disposal facility.

The EIPC site is in the high plains near the Texas–New Mexico border. The region experiences four seasons and generally low precipitation levels. The regional weather is dominated in the winter by a high-pressure system in the western United States and in the summer by a low-pressure system over Arizona. Winters are generally not severe, with temperatures only occasionally dropping below freezing. Summers are typically hot with low relative humidity levels (NUREG-2239).

19.3.2.1.2 Meteorological and Air Quality-Related Data Sources

Meteorological and air quality-related data are available from the sources described below.

a. Digital records from the National Weather Service (NWS) cooperative observing program (COOP).
   - COOP stations are operated by volunteer observers. These stations record parameters of particular interest to agricultural, industrial, and engineering applications. Depending on the station, those parameters include daily high and low dry bulb temperatures (DBTs), liquid precipitation, and snowfall.
   - COOP stations do not generally record humidity-related parameters, such as relative humidity, dew point, or wet bulb temperatures (WBTs); therefore, WBTs that are coincident with extreme DBTs, which are of interest in regional climate analysis, are generally not available from COOP stations. Meteorological data from cooperative observers are available from the National Centers for Environmental Information (NCEI) (NCEI, 2022a).

b. Digital records and other reports from automated surface weather observing stations.
   - Automated surface weather observing stations may be operated by NWS, the National Oceanic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), or other agencies. Hourly meteorological data files are available in TD-3505 format (NCEI, 2011) from NCEI (NCEI, 2022a) along with daily summaries (NCEI, 2022b).

c. Annual and monthly local climatological data (LCD) summaries from NCEI.
   - LCD annual summaries are typically available for meteorological stations at major airports and select automated weather stations. Those summaries include climatic normals, averages, and extremes. Thirty-year monthly histories are generally provided for the following parameters: mean temperature, total precipitation, total snowfall, and

heating/cooling degree days. The summaries also include the number of days with reports of specific weather phenomena, including thunderstorms and fog. The summaries also include a narrative description of the local climate. Monthly LCDs contain much of the same type of information as annual LCDs but are focused on a particular month of a specific year.

- Current LCDs are available for the automated weather observing stations at the Midland International Air and Space Port in Texas (station identifier KMAF; NCEI, 2022c) and Roswell in New Mexico (station identifier KROW; NCEI, 2022d).

d. Statistical summaries of climatological data from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) (ASHRAE, 2021).

   - ASHRAE provides climatic information for worldwide locations, including many U.S. airports and other locations with hourly surface weather observing stations. Parameters include dry bulb, wet bulb, and dew point temperatures. Also included are the statistical design values of dry bulb with mean coincident WBT, the design WBT with mean coincident DBT, and the design dew point with mean coincident DBT. ASHRAE also provides a methodology and key inputs for estimating extreme DBTs and WBTs for various return intervals.

e. American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) structural design standards (ASCE/SEI, 2017).

   - The ASCE/SEI standards provide minimum load requirements for the design of buildings and other structures that are subject to building code requirements. Particularly useful are 100-year maps with a wind gust mean return interval of three seconds (sec.). ASCE/SEI also provides maps of ground snow load with a 50-year return interval and a methodology for converting the 50-year values extracted from those maps to other return intervals.

f. 100-year return-interval, 48-hour (hr.) duration liquid equivalent precipitation.

   - The 100-year return-interval 48-hr. duration liquid equivalent precipitation is available for the EIPC from NOAA (NOAA, 2022).

g. Tornado and other weather event statistics from NCEI's online storm events database and "Storm Data" publications.

   - The storm events database (NCEI, 2022e) contains a chronological listing, by state and county, of climate statistics. Those statistics describe tornadoes, thunderstorms, hail, lightning, high winds, snow, temperature extremes, and other weather phenomena. Also included are statistics on personal injuries and property damage estimates.

   - The "Storm Data" publications are monthly summaries of severe weather events published by NCEI. These publications provide details about specific severe weather events.

h. Air quality summaries and air quality monitoring data from the U.S. Environmental Protection Agency (USEPA).

   - The USEPA provides maps and summaries of the current compliance status of counties that adhere to the National Ambient Air Quality Standards (NAAQS) (USEPA, 2022a).

   - The agency also provides digital summaries of measured concentrations and related parameters from air quality monitors (USEPA, 2022b). Concentrations from the monitors are used to assess compliance with the specific NAAQS.

19.3.2.1.3 Site Meteorological Data

Climatological parameters from the sources described above are presented in the following subsections. For the purposes of identifying a climate region with meteorological stations relatively close to the EIPC and subject to the same general climatic influences, this analysis concentrates on the three counties surrounding the EIPC: Lea County in New Mexico and Andrews and Gaines counties in Texas.

Table 19.3.2-1 lists the six COOP stations and the lone automated station relatively closest to the EIPC. Figure 19.3.2-1 shows the locations of the stations listed in Table 19.3.2-1.

The ground elevations shown in Table 19.3.2-1 are listed in meters above mean sea level (AMSL) because that is the measurement used by NOAA for describing the automated and COOP stations; however, the elevations in meters AMSL are functionally equivalent to the North American Vertical Datum of 1988 (NAVD 88) elevations used elsewhere in this report.

As shown in Table 19.3.2-1, and as noted above, six of the seven stations are COOP stations. As described in Subsection 19.3.2.1.2, COOP stations generally measure only daily temperature extremes and precipitation totals.

The other meteorological station is an automated station located at the Lea County Regional Airport, approximately 20 mi. (32 km) northwest of the EIPC (Figure 19.3.2-1). The Lea County Regional Airport (Hobbs, FAA) measures wind speed/direction, temperature, cloud cover, relative humidity, and precipitation. Hourly weather observations from the Lea County Regional Airport are publicly available from NWS (NWS, 2022).

Summaries of meteorological parameters measured at the Lea County Regional Airport (Hobbs, FAA) are available from the NCEI (NCEI, 2022b). The neighboring CISF uses data from the Lea County Regional Airport. Parameters measured during the most recent full five-year period (2017 – 2021) are summarized and compared with parameters reported in NUREG-2239 in Table 19.3.2-2.

Table 19.3.2-2 shows average DBTs from the Lea County Regional Airport for 2017 – 2021 and corresponding historical values for 1981 – 2020 from NUREG-2239. Average daily temperatures from Hobbs, via the FAA, for 2017 – 2021 are consistent with historical values; however, Table 19.3.2-2 shows that average monthly precipitation values for 2017 – 2021 are lower than those reported in NUREG-2239. The generally lower average monthly precipitation values for 2017 – 2021 reflect drought conditions recorded in the region during the period (NIDIS, 2022).

There is regulatory precedent for using airport data as an alternative to on-site meteorological data for reactor siting. Section 2.4.1 of NUREG/CR-2239, Technical Guidance for Siting Criteria Development, states, “NWS data have several potential advantages over reactor site data in that they are generally of higher quality, are readily available, contain more detailed observations, and are of durations up to 30 years.” As noted in PSAR Section 2.3, parameters such as wind speeds, wind directions, temperature and precipitation observed at the Lea Country Regional Airport (KHOB) were evaluated to determine the temporal and geographical representativeness of KHOB to the site.Lea County Regional Airport (KHOB) is located in the same geographic area as EIPC and satisfies the geographical representativeness criteria. Comparison of KHOB temperature and precipitation data to historical records is provided in the following sections.

19.3.2.1.4 Air Flow

As discussed in Subsection 19.3.2.1.3, the closest meteorological station with publicly available wind speed and direction data is the Lea County Regional Airport. A wind rose from the Lea County Regional Airport for 2010 – 2015 is provided in NUREG-2239. The predominate wind direction is from the south-southeast.

A wind rose for the most recent full five-year period (2017 – 2021) at the Lea County Regional Airport from NCEI (NCEI, 2022f) is shown in Figure 19.3.2-2. The most frequent wind direction is from the south to south-southeast, which is consistent with the wind rose in NUREG-2239. The EIPC uses meteorological data from the Lea County Regional Airport to support operations. Data from the Lea County Regional Airport are available from NWS (NWS, 2022).

19.3.2.1.5 Severe Weather

Lea, Andrews, and Gaines counties experience a variety of severe weather events. The NCEI storm events database (2023a) was queried to extract statistics on severe weather in the three-county area during 1950 – 2022. This updates the severe weather climatology provided through 2017 in NUREG-2239. Severe weather events through 2022 are listed in Table 19.3.2-3. Additional details are provided in the following subsections.

19.3.2.1.5.1 Tornadoes

Tornado intensity is classified according to the enhanced Fujita tornado intensity scale (EF scale). This scale matches the wind speeds to the degree of observed damage according to 28 indicators. Measuring tornadoes from EF1 to EF5, the EF scale uses more specific structural damage indicators than the original Fujita tornado intensity scale (F scale), which was established in 1971 (SPC, 2022). Table 19.3.2-4 shows the original F scale and EF scale for reference.

The NCEI storm events database (2022d) was queried to extract statistics on tornadoes observed in the three-county area during 1950 – 2021. Those tornadoes are summarized by their intensity in Table 19.3.2-5. Tornadoes with a rating of F2/EF2 – F5/EF5 are considered strong to violent. Of the 155 tornadoes recorded in the three-county area during the 71-year period, 139 were included in the lowest-severity categories (F0/EF0 and F1/EF1). The three-county area has experienced two F3/EF3 tornadoes during the 71-year period. This represents the most severe category of tornado experienced in the three-county area.

The NCEI storm events database (NCEI, 2022e) was queried to extract statistics on regional tornadoes observed within 50 mi. (80 km) of the EIPC during 1950 – 2021. Observed strong-to-violent (F2/EF2 – F5/EF5) intensity storms are summarized in Table 19.3.2-6. A total of 36 tornadoes of intensity F2/EF2 or greater were observed, four of which were of F3/EF3 intensity. This represents the most severe category of tornado experienced within 50 mi. (80 km) of the EIPC.

19.3.2.1.5.2 Thunderstorms

Thunderstorms are relatively frequent in the summer; they are accompanied by lightning and hail. When hail falls over an agricultural area, considerable crop damage may result (NMSU, 2022). Lightning and hail frequencies are described in the following subsections.

19.3.2.1.5.3 Lightning

The NCEI storm events database (NCEI, 2022e) was queried to extract statistics on observed lightning events in the three-county area around the EIPC during 1950 – 2021. A total of three events of sufficient intensity to cause fatalities, injury, and/or significant property damage were reported during 1950 – 2021.

The mean frequency of lightning strikes to earth is estimated via a method from the Electric Power Research Institute (EPRI), per the U.S. Department of Agriculture Rural Utilities Service (USDA, 1998). The method assumes a relationship between the average number of thunderstorm days per year (*T*), and the number of lightning strikes to earth per square mile (mi^2) per year (yr.) (*N*). The mathematical relationship is as follows:

$$N = [0.31][T] \qquad \text{(Equation 19.3.2-1)}$$

Current published values of the average number of thunderstorm days per year are available for the Midland International Air and Space Port in Texas (NCEI, 2022c) and Roswell in New Mexico (NCEI, 2022d). The Midland International Air and Space Port is located approximately 61 mi. (98 km) southeast of the EIPC, and Roswell is located approximately 103 mi. (166 km) northwest of the facility.

The number of lightning strikes to earth per mi^2/yr is computed for Roswell and Midland International Air and Space Port in Table 19.3.2-7. The average number of thunderstorm days per year at Midland International Air and Space Port is 34.5 (NCEI, 2022c), which is higher than the value of 29.2 days for Roswell (NCEI, 2022d). Using the higher of the two values, the estimated frequency of lightning strikes to earth per mi^2/yr at the EIPC is 10.7 (4.2 strikes per square kilometer [km^2]/yr).

For comparison, the 10-year period from 2009 to 2018 (Vaisala, 2018) indicates two to four flashes per km^2/yr around the EIPC. The EPRI value, therefore, is shown to be a reasonable indicator.

19.3.2.1.5.4 Hail

The NCEI storm events database (NCEI, 2023) was queried to extract statistics on observed hail in the three-county area around the EIPC for 1950 – 2022. As shown in Table 19.3.2-8, approximately 57 percent (490 out of 865 events) did not produce hailstones larger than 1 inch (in.) (2.54 centimeters [cm]) in diameter. During 1950 – 2022, 75 hail events with hailstones larger than 2 in. (5.08 cm), seven hail events with hailstones larger than 3 in. (7.62 cm), and eight hail events with hailstones larger than 4 in. (10.16 cm) were documented. The largest hailstone recorded during the period (5 in. [12.70 cm]) was observed in Gaines County on May 22, 1973. The hail was associated with a storm system that produced multiple reports of large hail in western Texas (NCEI, 1973).

19.3.2.1.5.5 High Winds

Relatively strong winds often accompany occasional frontal systems during the late winter and spring and may occur in advance of thunderstorms. Winds associated with frontal systems may exceed 30 miles per hour (mph) (13.4 meters per second [m/s]) for several hours and reach

peak speeds exceeding 50 mph (22.4 m/s). Blowing dust and soil erosion may result during dry periods. Strong winds often accompany thunderstorms that occasionally produce high, damaging winds (NMSU, 2022). Occurrences of high winds in the three-county area are summarized in Table 19.3.2-3.

19.3.2.1.5.5.1 100-Year Return-Interval Wind Gust

ASCE/SEI 7-16, Minimum Design Loads for Buildings and Other Structures, provides site-specific 100-year mean return-interval wind gusts. The 100-year, mean return-interval 3-sec gust wind speed at 33 feet (ft.) (10 meters [m]) above ground level (Exposure Category C) for the EIPC is 90 mph (40 m/s) (ASCE/SEI, 2017; Figure CC.2-4).

19.3.2.1.5.6 Heavy Rain

Summer rains fall almost entirely during brief, but frequently intense, thunderstorms. The general southeasterly circulation from the Gulf of Mexico brings moisture for these storms into New Mexico, and strong surface heating, combined with orographic lifting as the air moves over higher terrain, causes air currents and condensation. July and August are the wettest months over most of New Mexico, with approximately 30 – 40 percent of the annual total precipitation falling during those months (NMSU, 2022). Statistics on heavy rain events in the three-county area are summarized in Table 19.3.2-3.

Precipitation extremes are available from the COOP and automated monitoring stations near the EIPC. The stations were identified in Subsection 19.3.2.1.3.

Table 19.3.2-9 presents the maximum recorded daily (calendar day) liquid equivalent precipitation from the monitoring stations from NCEI (NCEI, 2022a). The maximum recorded daily liquid equivalent precipitation is 10.53 in. (26.74 cm) at Pearl, NM. The event occurred during July 20 – 21, 1975. NCEI describes the event as follows:

> Lea County: Continuous heavy rain with storm totals in excess of four inches blocked railroads and highways. Pooling water damaged many houses (NCEI, 1975).

19.3.2.1.5.6.1 100-Year Return-Interval, 48-hr. Duration Liquid Equivalent Precipitation

The approximate center of the Reactor Facility (RF) is described in Section 19.2.1. Point estimates of precipitation return intervals are available from NOAA (NOAA, 2022). Based on the location of the RF building, the 100-year return-interval, 48-hr. duration liquid equivalent precipitation is 7.27 in. (18.47 cm).

19.3.2.1.5.7 Snow and Ice

Winter precipitation is caused mainly by frontal weather systems associated with the general movement of Pacific Ocean storms across the country from west to east. As these systems move inland, much of the moisture is precipitated over the coastal and inland mountain ranges of California, Nevada, Arizona, and Utah. Much of the remaining moisture falls on the western slope of the Continental Divide and over northern and high central mountain ranges. Winter is the driest season in New Mexico except for the portion west of the Continental Divide. This dryness is most noticeable in the Central Valley and on the eastern slopes of the mountains of New Mexico (NMSU, 2022).

19.3.2.1.5.7.1 Snowfall

Table 19.3.2-9 presents maximum recorded daily (calendar day) snowfall at the local meteorological stations from NCEI (NCEI, 2022a). The maximum recorded daily snowfall for all of the stations is 15.0 in. (38.1 cm) at Nadine 2E in New Mexico; this was recorded on January 9, 2012. Table 19.3.2-9 also shows a maximum daily snowfall of 11.0 in. (27.9 cm) at Hobbs in New Mexico, which occurred on January 10, 2012. The heavy snowfall at both stations was associated with an upper-level storm system with high amounts of atmospheric moisture that moved through western Texas (NCEI, 2012).

19.3.2.1.5.7.2 100-Year Return-Interval Ground Snow Load

ASCE/SEI 7-16 (ASCE/SEI, 2017; Figure 7.2-1 and Table 7.2-6) provides the 50-year ground snow load for locations in New Mexico. Hobbs, NM, is the closest location with a published value. The 50-year ground snow load at Hobbs, NM, is 10 pounds per square foot (lb/ft^2) (48.8 kilograms per square meter [kg/m^2]).

ASCE/SEI 7-16 (ASCE/SEI, 2017, Section C7.3.3) provides a factor of 1.22 for estimating a 100-year return interval ground snow load from a 50-year ground snow load. The resulting 100-year ground snow load is 12.2 lb/ft^2 (59.6 kg/m^2).

19.3.2.1.5.7.3 Ice Storms

The NCEI storm events database (NCEI, 2022e) was queried to extract statistics on observed ice storm events in the three-county area around the EIPC during 1950 – 2021. Ice storms are defined as events producing ice accretions of 0.25 in. (0.64 cm) to 0.5 in. (1.27 cm) or more (NWS, 2021). A total of 19 events were observed.

The attendant formation of glaze from an ice storm on terrestrial objects creates hazards. Glaze is a coating of ice, generally clear and smooth, formed on exposed objects (AMS, 2012). Tattelman and Gringorten (Tattelman and Gringorten, 1973) estimated glaze and wind loads for eight regions (I – VIII) of the contiguous United States. The estimates were based on observed ice storms in which the maximum ice thickness of 2.5 cm (1 in.) or more and 5 cm (2 in.) or more occurred during a 50-year period. The state of New Mexico is in Region VIII, which includes all states along and west of the Continental Divide.

Only three ice storms met the criteria for their study in Region VIII. Due to this small sample size, estimates of maximum glaze thickness are not provided for Region VIII, including the state of New Mexico. For locations in Region VIII, Tattelman and Gringorten recommend use of estimated glaze thickness from Region III (New England), the most severe conditions documented in their study, as bounding values for glaze thickness. For Region III, the estimated maximum ice thickness is 5.8 cm (2.3 in.) for a 25-year return period and 7.2 cm (2.8 in.) for a 50-year return period (Tattelman and Gringorten, 1973; Table 6).

ASCE/SEI 7-16 (ASCE/SEI, 2017; Figure 10.4-2) provides an estimate of ice thickness and concurrent 3-sec. wind gusts for a 500-year recurrence interval. The 500-year ice thickness at the EIPC is approximately 1 in. (2.54 cm), and the concurrent 3-sec. wind gust is 40 mph (17.9 m/s).

ASCE/SEI 7-16 (ASCE/SEI, 2017; Table C10.4-1) provides multipliers for adjusting the 500-year ice thickness and concurrent wind gust to other recurrence intervals. The multipliers for ice

thickness and wind pressure for a 25-year recurrence interval are 0.40 and 1.0, respectively; thus, the 25-year ice thickness and concurrent wind gust is 0.40 in. (1 cm) and 40 mph (17.9 m/s).

From ASCE/SEI 7-16 (ASCE/SEI, 2017; Table C10.4-1), the multipliers for ice thickness and wind pressure for a 50-year recurrence interval are 0.50 and 1.0, respectively; thus, the 50-year ice thickness and concurrent wind gust are 0.50 in. (1.3 cm) and 40 mph (17.9 m/s).

19.3.2.1.5.8 Heavy Fog

Occurrences of heavy fog (defined as fog reducing the horizontal visibility to 0.25 mi. [0.40 km] or less) are available for Midland, TX, and Roswell, NM.

Table 19.3.2-10 summarizes the average number of days per month with heavy fog observed at Midland, TX, from NCEI (NCEI, 2022c). Heavy fog was observed for an average of 14.6 days per year and occurred most often during January and December.

Table 19.3.2-11 summarizes the average number of days per month with heavy fog observed at Roswell, NM, from NCEI (NCEI, 2022d). Heavy fog was observed for an average of approximately 11.9 days per year and most frequently during January and December, a similar annual trend to that observed at Midland, TX.

19.3.2.1.5.9 Extreme Dry and Wet Bulb Temperatures

19.3.2.1.5.9.1 Design Dry and Wet Bulb Temperatures

Design basis DBTs and WBTs are defined for the EIPC. They include the following temperatures:

1. Maximum DBT with an annual exceedance probability of 0.4 percent.
2. Mean coincident WBT at the 0.4-percent DBT.
3. Maximum DBT with an annual exceedance probability of 1.0 percent.
4. Mean coincident WBT at the 1.0-percent DBT.
5. Maximum DBT with an annual exceedance probability of 2.0 percent.
6. Mean coincident WBT at the 2.0-percent DBT.
7. Minimum DBT with an annual exceedance probability of 1.0 percent.
8. Minimum DBT with an annual exceedance probability of 0.4 percent.
9. 100-year return maximum annual DBT.
10. 100-year return maximum non-coincident annual WBT.

Design temperatures for (1) – (10) are available from ASHRAE (ASHRAE, 2021). Design temperatures for Midland, TX, are listed in Table 19.3.2-12.

The 100-year return-interval maximum annual DBTs and WBTs (Items [9] and [10] above) were estimated using a technique described by ASHRAE (ASHRAE, 2021). The technique estimates the n-year return-interval extreme maximum or minimum temperature using the mean and standard deviation of a series of annual maximum and minimum temperatures. This technique uses the following equation:

$$T_n = M + I\,F\,s \qquad \text{(Equation 19.3.2-2)}$$

where:

- T_n = n-year return period value of the extreme DBT to be estimated, years.
- M = mean of annual extreme maximum or minimum DBTs, degrees Fahrenheit (°F).
- I = 1 if maximum DBTs are being considered; -1 if minimum DBTs are being considered.
- s = standard deviation of annual extreme maximum or minimum DBTs, °F.
- n = return period in years (n = 100 for a 100-year return interval).
- F = Equation 19.3.2-3.

$$F = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{n}{n-1}\right)\right]\right\} \qquad \text{(Equation 19.3.2-3)}$$

ASHRAE (ASHRAE, 2021) provides the mean annual extreme maximum and mean annual extreme minimum temperature (M) and the corresponding standard deviations (s) in Equation 19.3.2-2 for the Midland International Air and Space Port in Texas.

The inputs, computed 100-year return interval maximum annual DBTs, and non-coincident WBTs computed for the Midland International Air and Space Port from Equation 19.3.2-2 and Equation 19.3.2-3 are listed in Table 19.3.2-13.

19.3.2.1.5.9.2 Record Dry Bulb Temperatures

An additional review of regional extreme DBTs is done using local meteorological stations. The stations are listed in Table 19.3.2-1, and their respective locations are shown on Figure 19.3.2-1.

Table 19.3.2-14 presents record DBTs recorded at the local weather stations. Table 19.3.2-14 shows that the overall extreme DBTs are a maximum of 118°F (47.8 degrees Celsius [°C]) recorded on June 28, 1994, in Ochoa, NM, and a minimum of -11°F (-23.8°C) recorded at Lea County Regional Airport on February 1, 1951, as well as at Pearl, NM, on both February 1, 1951, and January 29, 1948.

19.3.2.1.5.10 Atmospheric Stagnation

Major air pollution episodes are typically a result of persistent surface high-pressure weather systems that cause light and variable surface winds and stagnant meteorological conditions for four or more consecutive days. Estimates of the stagnation frequency are provided by NOAA, (Wang and Angell, 1999; Figure 1 and Figure 2). Those estimates indicate that, on average, the EIPC experiences approximately 50 days with stagnation per year. When occurring, stagnation lasts approximately six days.

19.3.2.1.5.11 Mixing Heights

The mixing height is the height to which vigorous turbulence tends to mix pollutants (AMS, 2012). Mixing heights vary during the day. At the EIPC location, the estimated lowest average mixing heights (approximately 400 m – 500 m [1300 ft. – 1650 ft.]) generally are recorded during the morning hours, and the highest readings (approximately 2000 m – 2400 m [6600 ft. – 7900 ft.]) are recorded during the afternoon (Holzworth, 1972).

19.3.2.1.6 Ambient Air Quality Standards

The Clean Air Act requires the USEPA to set NAAQS for pollutants considered harmful to public health and the environment. It identifies two types of NAAQS. Primary NAAQS provide public health protection, including that of sensitive populations, such as asthmatics, children, and the elderly. Secondary NAAQS provide public welfare protection, including that against decreased visibility and damage to animals, crops, vegetation, and buildings (USEPA, 2022a).

The USEPA has specified NAAQS for six principal pollutants, which are called “criteria pollutants.” The criteria pollutants include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2). Particulate matter includes particulate matter with an aerodynamic diameter less than 2.5 micrometers (µm) ($PM_{2.5}$) and particulate matter with an aerodynamic diameter less than 10 µm (PM_{10}). The criteria pollutants and their respective NAAQS are listed in Table 19.3.2-15 (USEPA, 2022a).

States may impose stricter ambient air quality standards than the NAAQS. New Mexico has additional ambient air quality standards for CO, NO_2, SO_2, hydrogen sulfide (H_2S), and total reduced sulfur (TRS) (USEPA, 2011a). These additional standards for New Mexico are listed in Table 19.3.2-16.

The New Mexico Environment Department (NMED) is responsible for issuing permits and enforcing compliance with environmental regulations and standards, including air quality standards. The EIPC complies with applicable regulations.

19.3.2.1.7 Regional Air Quality

Lea County in New Mexico is part of the Pecos-Permian Basin Intrastate Air Quality Control Region (USEPA, 2011b). Air quality monitors measure concentrations of criteria pollutants to demonstrate attainment with the respective NAAQS. The closest air quality monitoring station to the EIPC is located in Hobbs, NM. This monitoring station is operated by the NMED. The monitor measures NO_2, O_3, and $PM_{2.5}$.

Lea County, NM, is designated as attainment for all criteria pollutants (USEPA, 2022c). The closest area designated as non-attainment with one or more NAAQS is Howard County, TX. A

portion of Howard County is not in attainment for the 1-hr. SO_2 NAAQS (USEPA, 2022c). Howard County is located approximately 80 mi. (130 km) east of the EIPC.

Criteria pollutant emissions aggregated at the county level from NUREG-2239 are provided in Table 19.3.2-17 for Lea County in New Mexico and Andrews and Gaines counties in Texas. The emissions include contributions from stationary and mobile sources. Table 19.3.2-17 provides pollutant levels that characterize the existing ambient air quality conditions.

19.3.2.1.7.1.1 Class I Areas

Class I areas are national parks and wilderness areas that are potentially sensitive to visibility impairment. USEPA (USEPA, 1990) states that a Class I visibility impact analysis is necessary for a major source within 100 km (62 mi.) of a Class I area.

Table 19.3.2-18 lists the nearest mandatory (federal) or American Indian Class I areas to the EIPC (USEPA, 2022d; NPS, 2022a). The table shows three Class I areas:

- Carlsbad Caverns National Park, approximately 88 mi. (142 km) west of the proposed facility.
- Guadalupe Mountains National Park, about 112 mi. (180 km) west-southwest of the proposed facility.
- Salt Creek Wilderness Area, approximately 113 mi. (182 km) northwest of the proposed facility.

19.3.2.1.7.1.2 Federal Regulations

In 2010, the USEPA promulgated the Tailoring Rule to address greenhouse gas (GHG) emissions under the Clean Air Act permitting programs. As initially promulgated, the Tailoring Rule specified that new sources, as well as existing sources, with the potential to emit more than 100,000 tons/yr of carbon dioxide equivalent (CO_2e) were subject to USEPA permitting requirements. Modifications of existing facilities that increase GHG emissions by at least 75,000 tons/yr are also subject to permitting requirements. Subsequent revisions to the Tailoring Rule have not resulted in different GHG emission thresholds (NUREG-2239).

19.3.2.1.7.1.3 State of New Mexico GHG Regulations

In 2022, the New Mexico state legislature considered a bill to achieve “net zero” GHG emissions by 2050 (New Mexico State Legislature, 2022a). This bill did not pass (New Mexico State Legislature, 2022b); however, the ultimate course of any successors to this proposed legislation is uncertain.

The EIPC complies with Federal and State environmental regulations related to emissions of GHGs and other regulated pollutants.

Site preparation, construction, operation, and decommissioning of the EIPC are expected to result in emissions of carbon dioxide (CO_2) and other GHGs through various mechanisms, primarily from the combustion of fossil fuels in mobile and stationary sources.

GHG emissions control strategies are discussed in Section 19.4.

19.3.2.1.8 Greenhouse Gases

GHGs, which can absorb heat in the atmosphere, are produced by numerous sources, including fossil fuels and agricultural and industrial processes. Global GHG emissions are estimated to be 49 gigatons of CO_2e and have been consistently rising in recent decades (Edenhofer et al., 2014). At the national level, net GHG emissions in the United States are 5903 million metric tons CO_2e (2018 emission levels; USEPA, 2020). During recent years, net GHG emissions in the United States increased by 3.1 percent from 2017 to 2018 but have decreased by 10.2 percent from 2005 levels. The decline reflects long-term trends, including population growth, energy market trends, and technological trends such as energy efficiency and energy fuel choices. Between 2017 and 2018, the increase in GHG emissions was largely driven by an increase in CO_2 emissions from fossil fuel combustion. This year-over-year increase in CO_2 emissions from fossil fuel combustion was a result of multiple factors, including increased energy use from greater heating and cooling needs due to a colder winter and hotter summer in 2018 compared with that of 2017 (USEPA, 2020). Present-day CO_2 concentrations in the atmosphere are around 400 parts per million (ppm). By the year 2100, these levels are expected to range from 450 ppm to 936 ppm (USGCRP, 2017). New Mexico has an objective to reduce statewide GHG emissions by at least 45 percent by 2030 compared to GHG levels in 2005 as described in the New Mexico Climate Strategy based on Executive Order 2019-003 signed by Governor Lujan Grisham (New Mexico Interagency Climate Change Task Force, 2019).

19.3.2.2 Noise

19.3.2.2.1 Background and Applicable Noise Level Standards

Any pressure variation that can be detected by the human ear is considered *sound*, and *noise* is defined as unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured by using the logarithmic decibel (dB) scale. Given that the human ear cannot perceive all pitches or frequencies, noise measurements are typically weighted to correspond to the limits of human hearing. This adjusted unit of measure is known as the A-weighted decibel (dBA), which is designed to simulate human hearing by placing less emphasis on lower-frequency noises. Because the human ear does not perceive sounds at low frequencies in the same manner as sound at higher frequencies, higher frequencies receive less A-weighting than lower ones. Additionally, in noise measurements, sound pressure levels are typically averaged over a given length of time, because instantaneous levels can vary widely. Typical indoor and outdoor sound levels, in the dBA scale, are shown in Figure 19.3.2-3 (OSHA, 2013).

The intensity of sound decreases with increasing distance from the source. Typically, sound levels for a point source decrease by 6 dBA for each doubling of distance. This decrease in intensity may vary depending on the terrain, topographical features, and frequency of the noise source. Generally, sound level changes of 3 dBA or less are barely perceptible, while a change of 5 dBA is readily noticeable by most listeners. A 10-dBA increase is usually perceived as a doubling of loudness, as documented in NUREG-2239.

The project site is located in Lea County, NM, which has established a noise-control ordinance prohibiting excessive noise during nighttime hours (between 10:00 p.m. and 6:00 a.m.). Sound projecting from a property during nighttime hours should not exceed 50 dBA at the boundary of the property immediately adjacent to the property from which the sound emanates. These nighttime limits apply to the operation of machinery, equipment, fans, and air conditioners as

well as construction, repair, demolition, excavation, and grading work (except for cases of emergency work necessary to restore property to a safe condition, restore public utilities, or protect persons or property from imminent danger). No daytime noise limits have been established (Lea County, 2019). Additionally, no other municipal or state ordinances or regulations governing environmental noise are applicable to the project site. In addition, there are no Native American tribal agencies in proximity to the project site that are affected by on-site noise; thus, no local, tribal, or state noise regulations governing noise emissions from the project site apply to the project apart from the Lea County nighttime noise-control ordinance.

At the federal level, the USEPA has a broad-ranging set of guidelines for environmental noise levels. USEPA guidelines recommend that outdoor noise levels do not exceed a day–night average noise level (L_{dn}) of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas. This level is not a regulatory standard but is intentionally conservative to protect the most sensitive portion of the American population with an additional margin of safety (USEPA, 1974). In addition, NRC guidance (NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan) states that noise levels are acceptable if the L_{dn} outside a residence is less than 65 dBA, which is consistent with the U.S. Department of Housing and Urban Development regulations for exterior noise standards (HUD, 1985).

19.3.2.2.2 Previous Noise Studies

Two previous studies of environmental noise have been performed at properties in proximity to the project site. In September 2003, Louisiana Energy Services, LLC (now doing business as Urenco USA) conducted a background noise level survey at the URENCO property (approximately 1.3 mi. [2.1 km] northeast of the project site center point) prior to construction of the URENCO National Enrichment Facility. Measurements were taken at the four corners of the URENCO property boundary, and recorded background noise levels ranged from 40.1 dBA to 50.4 dBA (NRC, 2015). While it is likely that noise levels at the URENCO site have since increased somewhat in association with facility operation, the 2003 noise study provides an estimate of baseline ambient noise levels for a vacant/undeveloped site in the project vicinity that is representative of the current conditions at the EIPC project site.

In July 2019, background noise level measurements were collected at five locations on the WCS disposal site, located approximately 2.6 mi. (4.2 km) northeast of the project site center point. Noise data were collected from three locations along the western boundary of the WCS property and from two locations near the proposed CISF project area, which is adjacent to the existing WCS LLW facility to the north. Measured background levels at these locations ranged from 36.3 dBA within the proposed CISF project area to 43.8 dBA near the western boundary of the WCS site, which borders the URENCO site. Roadway traffic on NM-176 was the primary contributor to background noise levels (NUREG-2239).

To date, no noise measurements have been conducted at the project site itself; however, the studies discussed herein are considered representative of the baseline noise conditions in the area that are applicable to the EIPC project site; thus, current noise levels at the project site are expected to be similar to or lower than the L_{dn} for quiet to normal suburban areas, which typically range from 48 dBA to 57 dBA (USEPA, 1974).

19.3.2.2.3 Noise-Generating Facilities and Activities

As noted in Subsection 19.3.1.1, the project site is located in a sparsely populated area of southeastern New Mexico consisting predominantly of undeveloped scrub/shrub land. Because no existing structures or infrastructure are located within the project site boundary, the primary source of noise consists of vehicle traffic on NM-176, adjacent to the project site to the north, and on NM-18 to the west (Figure 19.3.1-3). Other sources of noise in the area include natural elements, such as wind gusts, bird calls, aircraft flyover from the Lea County Regional Airport, oil and gas industry activities, and operational activities at the following neighboring commercial and industrial facilities:

- URENCO National Enrichment Facility, approximately 1.3 mi. (2.1 km) to the northeast, consisting predominantly of commuter and truck traffic.
- Lea County Sanitary Waste Landfill, approximately 1.6 mi. (2.6 km) to the east, consisting predominantly of front-end loaders, graders, and heavy-haul truck traffic.
- The Sundance Services oil recovery and solids disposal facility, approximately 1.9 mi. (3.1 km) to the north, consisting predominantly of heavy-haul truck traffic and roll-off and container services.
- The Permian Basin Materials sand and gravel quarry, approximately 2.4 mi. (3.8 km) to the west, consisting of front-end loaders, conveyers, ready-mix concrete plants, and heavy-haul truck traffic.
- WCS's hazardous waste and LLW disposal facilities, approximately 2.6 mi. (4.2 km) to the northeast, consisting of commuter and truck traffic, operating equipment (e.g., cranes, canister transport vehicles, and heavy-haul truck traffic), and rail and tractor-trailer traffic associated with waste shipments.

19.3.2.2.4 Sensitive Noise Receptors

Noise-sensitive receptors that could be vulnerable to noise associated with the proposed action include land uses such as residences, hotels, motels, active sport areas, schools, places of worship, hospitals, parks, and other public buildings or developed sites where frequent public use occurs. Based on a review of aerial photographs, the closest noise-sensitive receptors to the project site are residences located west of NM-18, approximately 1.7 mi. (2.7 km) to the west of the project site boundary. Additionally, the closest noise-sensitive receptor to the off-site utility corridor are residences located west of NM-18, ranging from approximately 0.27 mi. (0.43 km) to the corridor on the north side of NM-18, to 0.39 mi. (0.63 km) to the corridor on the south side of NM-18.

Apart from residences, the nearest noise-sensitive land uses (including multiple places of worship, schools, a cemetery, and a municipal park) are located to the west within the City of Eunice municipal boundary, at distances of more than 3.0 mi. (4.8 km) from the project site.

Table 19.3.2-1
Local Meteorological Stations

Station	Type	County	Latitude (degrees)	Longitude (degrees)	Elevation (m, AMSL)	Period of Record
Hobbs	Cooperative	Lea	32.72630	-103.1313	1115.6	1912 – 2020
Hobbs 13 W	Cooperative	Lea	32.71250	-103.3538	1169.2	1996 – 2015
Lea County Regional Airport (KHOB; Hobbs FAA)	Automated station	Lea	32.69330	-103.2125	1114.0	1941 – 2022
Monument 1.2 W	Cooperative	Lea	32.62481	-103.2860	1097.9	2012 – 2022
Nadine 2 E	Cooperative	Lea	32.62360	-103.0842	1001.3	2009 – 2022
Ochoa	Cooperative	Lea	32.16640	-103.4249	1035.7	1942 – 2019
Pearl	Cooperative	Lea	32.65000	-103.3833	1158.2	1906 – 1996

Abbreviations: m = meter(s) | AMSL = above mean sea level | FAA = Federal Aviation Administration

Table 19.3.2-2
(Sheet 1 of 2)
Climate Summary from Lea County Regional Airport (KHOB), New Mexico (2017 – 2021)

Month	Dry Bulb Temperature (°C)			Dew Point Temperature (°C)	Wind Speed (m/s)	Liquid Equivalent Precipitation (cm)
	Average Daily Maximum	Average Daily Minimum	Average Daily	Average Daily	Average Daily	Average Monthly
January	13.9	-1.3	5.7	-5.9	4.6	0.51
February	16.8	-0.1	7.6	-5.6	4.8	0.04
March	21.7	5.3	13.0	-1.5	5.1	1.00
April	26.1	8.2	16.5	-0.3	5.4	1.26
May	30.8	13.8	22.3	5.0	5.3	0.65
June	34.7	18.5	26.6	10.7	4.8	2.53
July	34.4	20.2	27.3	13.4	4.1	0.85
August	34.0	19.9	26.8	14.0	3.9	2.61
September	30.1	15.8	22.5	12.1	3.9	1.55
October	24.8	9.1	16.2	4.4	4.5	1.21
November	19.5	3.4	10.7	-0.8	4.5	0.39
December	15.8	-0.1	7.0	-5.6	4.6	0.34

Abbreviations: °C = degrees Celsius | m/s = meters per second | cm = centimeter(s)

Table 19.3.2-2
(Sheet 2 of 2)
Climate Summary from Lea County Regional Airport (KHOB), New Mexico (2017 – 2021)

Month	Average Daily Dry Bulb Temperature (°C)		Average Daily Minimum Dry Bulb Temperature (°C)		Average Daily Maximum Dry Bulb Temperature (°C)		Average Monthly Precipitation (cm)	
	Hobbs, FAA 1981 – 2010 (NUREG-2239)	Hobbs, FAA (2017 – 2021)	Hobbs, FAA 1981 – 2010 (NUREG-2239)	Hobbs, FAA (2017 – 2021)	Hobbs, FAA 1981 – 2010 (NUREG-2239)	Hobbs, FAA (2017 – 2021)	Hobbs, FAA 1981 – 2010 (NUREG-2239)	Hobbs, FAA (2017 – 2021)
January	6.44	5.7	-1.17	-1.3	14.1	13.9	2.1	0.51
February	8.67	7.6	0.56	-0.1	16.7	16.8	1.8	0.04
March	12.4	13.0	3.72	5.3	21.1	21.7	1.8	1.00
April	17.3	16.5	8.33	8.2	26.3	26.1	2.7	1.26
May	22.1	22.3	13.3	13.8	30.9	30.8	6.0	0.65
June	26.2	26.6	17.7	18.5	34.7	34.7	4.5	2.53
July	27.2	27.3	19.5	20.2	34.8	34.4	6.9	0.85
August	26.4	26.8	19.2	19.9	33.8	34.0	5.3	2.61
September	22.8	22.5	15.3	15.8	30.2	30.1	6.9	1.55
October	17.6	16.2	9.67	9.1	25.4	24.8	3.5	1.21
November	11.1	10.7	3.17	3.4	19.0	19.5	2.1	0.39
December	6.33	7.0	-1.44	-0.1	14.1	15.8	1.9	0.34

Abbreviations: °C = degrees Celsius | m/s = meters per second | cm = centimeter(s) FAA = Federal Aviation Administration

Table 19.3.2-3
Severe Weather Events Reported in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2022

	Number of Events			
Type of Event	**Andrews County**	**Gaines County**	**Lea County**	**Description of Event [a]**
Flash Flood	43	66	82	A life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam).
Hail	190	222	457	Frozen precipitation in the form of balls or irregular lumps of ice. Although the minimum size of hail qualifying as “severe” is 1 in. (2.54 cm) in diameter, reports of hail 0.75 in. (1.88 cm) or larger in diameter is reported. Observed hail accumulations of smaller sizes, or instances where hail accumulates to a measurable depth that cause property and/or crop damage, are also reported. Injuries or fatalities that result from hail of any size are reported as well.
Heavy Rain	236	237	4	Unusually large amount of rain that does not cause a flash flood or flood event but causes damage.
High Wind	12	22	69	Sustained non-convective winds of 40 mph (18.0 m/s) or greater lasting for 1 hr. or longer, or gusts of 58 mph (25.7 m/s) or greater for any duration.
Thunderstorm Wind	206	247	225	Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 58 mph (25.7 m/s), or winds of any speed producing a fatality, injury, or damage.
Tornado	25	37	93	A violently rotating column of air, extending to or from a cumuliform cloud or underneath a cumuliform cloud, to the ground, and often (but not always) visible as a condensation funnel.

a) Event descriptions extracted from NWS, 2021.
Abbreviations: in. = inch(es) | cm = centimeter(s) | mph = miles per hour | m/s = meters per second | hr. = hour(s)

Table 19.3.2-4
Fujita Scale and Enhanced Fujita Scales to Determine Tornado Intensity

F scale	Fastest 1/4-mi. (mph)	3-sec. gust (mph)	EF scale	3-sec. gust (mph)
0	40 –72	45 – 78	0	65 – 85
1	73 – 112	79 – 117	1	86 – 110
2	113 – 157	118 – 161	2	111 – 135
3	158 – 207	162 – 209	3	136 – 165
4	208 – 260	210 – 261	4	166 – 200
5	261 – 318	262 – 317	5	over 200

Abbreviations: F = Fujita scale| mi. = mile(s) | mph = miles per hour | sec. = second(s) | EF = Enhanced Fujita scale

Table 19.3.2-5
Intensity of Tornadoes Reported in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2021

County	Tornado Intensity					
	F0/EF0	F1/EF1	F2/EF2	F3/EF3	F4/EF4	F5/EF5
Andrews	13	10	2	0	0	0
Gaines	26	6	4	1	0	0
Lea	64	20	8	1	0	0
Total	**103**	**36**	**14**	**2**	**0**	**0**

Abbreviations: F = Fujita scale | EF = Enhanced Fujita scale

Table 19.3.2-6
Summary of the Highest Intensity Tornadoes Observed within 50 mi. (80 km) of the EIPC from 1950 to 2021

State	County	Date	Tornado Intensity
New Mexico	Lea	5/17/1954	F3
Texas	Winkler	5/30/1955	F2
Texas	Yoakum	5/15/1957	F2
New Mexico	Lea	7/24/1960	F2
Texas	Terry	5/20/1961	F2
Texas	Gaines	6/18/1961	F2
Texas	Ector	7/21/1961	F2
Texas	Andrews	6/16/1962	F2
Texas	Gaines	4/19/1969	F3
Texas	Ector	6/3/1969	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/12/1971	F2
Texas	Terry	8/13/1971	F2
New Mexico	Lea	6/14/1972	F2
Texas	Ector	5/12/1973	F2
New Mexico	Eddy	4/30/1976	F2
Texas	Terry	6/3/1981	F2
Texas	Ector	10/15/1981	F2
Texas	Andrews	5/12/1982	F2
Texas	Gaines	5/12/1982	F2
New Mexico	Lea	5/27/1982	F2
New Mexico	Eddy	5/31/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Lea	6/6/1991	F2
New Mexico	Eddy	6/7/1992	F2
Texas	Gaines	4/10/1997	F2
Texas	Loving	4/30/1999	F2
New Mexico	Lea	3/23/2007	EF2
Texas	Ector	5/14/2010	EF3
Texas	Ector	3/18/2012	EF2
Texas	Gaines	11/16/2015	EF2
New Mexico	Eddy	3/12/2019	EF2
Texas	Ector	5/20/2019	EF3

Abbreviations: EIPC = Eden Isotope Production Complex | mi. = mile(s) | km = kilometer(s) | EF = Enhanced Fujita scale | F = Fujita scale

Table 19.3.2-7
Computed Lightning Strike Density at Roswell, New Mexico and Midland, Texas

Station	Thunderstorm Days	Period of Record	Computed Number of Lightning Strikes per Square Mile
Midland	34.5	1948 – 2022	10.7
Roswell	29.2	1953 – 2022	9.1

Table 19.3.2-8
Summary of Observed Hail in Andrews (Texas), Gaines (Texas), and Lea (New Mexico) Counties from 1950 to 2022

Hail Diameter (in.)	Number of Events
≤ 1.0 in.	490
1 ≤ 2.0 in.	285
2 ≤ 3.0 in.	75
3 ≤ 4.0 in.	7
> 4 in.	8
Total	**865**

Abbreviations: in. = inch(es)

Table 19.3.2-9
Maximum Daily Liquid Equivalent Precipitation and Snowfall from Local Meteorological Stations

Weather Observing Station	Maximum Daily Liquid Equivalent Precipitation (in.)	Maximum Daily Snowfall (in.)
Hobbs	7.5	11.0
Hobbs 13 W	4.5	4.0
Lea County Regional Airport (Hobbs FAA)[(a)]	3.63	9.0
Monument 1.2 W	3.73	8.0
Nadine 2 E	4.6	**15.0**
Ochoa	6.4	9.0
Pearl	**10.53**	**10.0**

a) Compiled using data available from WRCC (2022) for 1941 – 2016 and NCEI (2022f) for 2016 – 2021.
Note: Bold text denotes extremes.
Abbreviations: in. = inch(es) | FAA = Federal Aviation Administration

Table 19.3.2-10
Average Number of Days with Heavy Fog at Midland, Texas

	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Average Number	3.3	2.4	1.1	0.6	0.4	0.1	0.0	0.1	0.5	1.2	2.2	2.7	14.6

Source: NCEI, 2022c
Note: Based on 58 years of data.

Table 19.3.2-11
Average Number of Days with Heavy Fog at Roswell, New Mexico

	Month												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Average Number	2.4	1.8	0.8	0.3	0.3	0.1	0.1	0.1	0.7	1.5	1.8	2.0	11.9

Source: NCEI, 2022d
Note: Based on 53 years of data.

Table 19.3.2-12
Design Dry Bulb and Wet Bulb Temperatures

Station	Dry Bulb Temperature (°F)		Dry Bulb/Mean Coincident Wet Bulb Temperature (°F)		
	99.6%	99.0%	0.4%	1%	2%
Midland International Air and Space Port (1994 – 2019)	20.7	24.6	101.6 / 67.2	99.2 / 67.4	97.0 / 67.5

Source: ASHRAE, 2021
Abbreviations: °F = degree Fahrenheit

Table 19.3.2-13
Computed 100-Year Return-Interval Extreme Temperatures

	Means and Standard Deviations of Extreme Annual Temperatures (°F) at Midland International Air and Space Port, Texas (1994 – 2019) [a]				Computed 100-Year Return Interval Extreme Temperatures (°F)	
	Mean		Std. Deviation			
	Min.	Max.	Min.	Max.	Min.	Max.
Dry Bulb	14.2	106.2	3.5	3.4	3.2	116.9
Wet Bulb (Non-Coincident)	12.2	74.5	3.2	1.3	2.2	78.6

a) from ASHRAE, 2021.
Abbreviations: °F = degree Fahrenheit

Table 19.3.2-14
Daily Maximum and Minimum Dry Bulb Temperatures from Local Meteorological Stations

Observing Station	Dry Bulb Temperature (°F)	
	Maximum	**Minimum**
Hobbs	114	-7
Hobbs 13 W	113	1
Lea County Regional Airport (Hobbs FAA) [a]	108	**-11**
Monument 1.2 W [b]	--	--
Nadine 2 E [b]	--	--
Ochoa	**118**	-6
Pearl	109	**-11**

a) Compiled using data available from WRCC (2022) for 1941 – 2016 and NCEI (2022f) for 2016 – 2021.
b) Temperature not measured at this station.
Note: Bold text denotes extremes.
Abbreviations: °F = degree Fahrenheit | FAA = Federal Aviation Administration

Table 19.3.2-15
National Ambient Air Quality Standards

Pollutant	Primary/ Secondary Standard	Averaging Period	Level ($\mu g/m^3$)	Level (ppm)
CO [a]	Primary	1 hr.	--	35
CO [a]	Primary	8 hr.	--	9
Pb [b]	Primary and secondary	Rolling 3-month average	0.15	--
NO_2 [c]	Primary	1 hr.	--	0.1
NO_2	Primary and secondary	Annual	--	0.053
O_3 [d]	Primary and secondary	8 hr.	--	0.070
$PM_{2.5}$ [e]	Primary and secondary	24 hr.	35	--
$PM_{2.5}$	Primary	Annual	12.0	--
$PM_{2.5}$	Secondary	Annual	15.0	--
PM_{10} [f]	Primary and secondary	24 hr.	150	--
SO_2 [g]	Primary	1 hr.	--	0.075
SO_2 [a]	Secondary	3 hr.	--	0.5

a) Not to be exceeded more than once per year.
b) In areas designated nonattainment for the Pb standards prior to promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have been submitted and approved, the previous standards (1.5 $\mu g/m^3$ calendar quarter average) also remain in effect.
c) 98th percentile of 1-hr. daily maximum concentrations averaged over three years.
d) Annual fourth-highest daily maximum 8-hr. concentration averaged over three years.
e) 98th percentile averaged over three years.
f) Not to be exceeded more than once per year on average over three years.
g) 99th percentile of 1-hr. daily maximum concentrations averaged over three years.
Abbreviations: $\mu g/m^3$ = micrograms per cubic meter | ppm = parts per million | CO = carbon monoxide | hr. = hour(s) | Pb = lead | NO_2 = nitrogen dioxide | O_3 = ozone | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | SO_2 = sulfur dioxide

Table 19.3.2-16
New Mexico Ambient Air Quality Standards

Pollutant	Averaging Period	Level (ppm)	Form	Note
CO	1 hr.	13.1	Not to be exceeded	--
CO	8 hr.	8.7	Not to be exceeded	--
NO_2	24 hr.	0.10	Not to be exceeded	--
NO_2	Annual	0.05	Not to be exceeded	--
SO_2	3 hr.	0.50	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
SO_2	24 hr.	0.10	Not to be exceeded	--
SO_2	24 hr.	0.14	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
SO_2	Annual	0.02	Not to be exceeded	--
SO_2	Annual	0.03	Not to be exceeded	If within 3.5 mi. of Chino Mines Company smelter furnace at Hurley
H_2S	0.5 hr.	0.100	Not to be exceeded	For the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	0.5 hr.	0.030	Not to be exceeded	Within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	0.5 hr.	0.03	Not to be exceeded	Within 5 mi. of the corporate limits of municipalities having a population of greater than 20,000 and within the Pecos-Permian Basin Intrastate Air Quality Control Region
H_2S	1 hr.	0.010	Not to be exceeded	For the state except the Pecos-Permian Basin Intrastate Air Quality Control Region
TRS	0.5 hr.	0.003	Not to be exceeded	For the state except the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.010	Not to be exceeded	For the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.003	Not to be exceeded	For within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S
TRS	0.5 hr.	0.003	Not to be exceeded	For within 5 mi. of the corporate limits of municipalities having a population of greater than 20,000 and within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for H_2S

Abbreviations: ppm = parts per million | CO = carbon monoxide | hr. = hour(s) | NO_2 = nitrogen dioxide | SO_2 = sulfur dioxide | mi. = mile(s) | H_2S = hydrogen sulfide | TRS = total reduced sulfur

Table 19.3.2-17
Annual Air Pollutant Emissions for Lea County, New Mexico, and Andrews and Gaines Counties, Texas

County	Pollutant (metric tons/yr) [a]						
	CO	HAPs	NO_2	$PM_{2.5}$	PM_{10}	SO_2	VOCs
Lea, NM	27,698	10,959	15,626	2029	13,104	5037	88,614
Andrews, TX	11,925	4586	8331	282	904	1785	49,567
Gaines, TX	8132	3358	4162	1182	5716	532	31,254
Total	**47,755**	**18,903**	**28,119**	**3493**	**19,724**	**7354**	**169,435**

a) Emissions from NUREG-2239, Table 3.7-4.
Abbreviations: yr. = year(s) | CO = carbon monoxide | HAPs = hazardous air pollutants | NO_2 = nitrogen dioxide | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | SO_2 = sulfur dioxide | VOCs = volatile organic compounds | NM = New Mexico | TX = Texas

Table 19.3.2-18
Nearest Federal Class I Areas to the EIPC

Class I Area [(a)]	Distance from the EIPC (km)	Direction from the EIPC
Carlsbad Caverns National Park, New Mexico	142	west
Guadalupe Mountains National Park, Texas	180	west-southwest
Salt Creek Wilderness Area, New Mexico	182	northwest

a) Distances extracted from USEPA (2022d) and NPS (2022a).
Abbreviations: EIPC = Eden Isotope Production Complex | km = kilometers

19.3.3 GEOLOGIC ENVIRONMENT

This section provides a description of the regional and local geology and identifies the characteristics of the soil and mineral resources at the proposed project site in Lea County, NM.

19.3.3.1 Geologic Description

19.3.3.1.1 Regional Physiography

The project site as well as nearby portions of southeast New Mexico and southwest Texas are located in the southern portion of the Great Plains physiographic province. In the vicinity of the project site, the southern Great Plains is also known as the High Plains province and is bordered to the west by the Pecos Valley province (Figure 19.3.3-1). Figure 19.3.3-2 is a physiographic map of southern Lea County showing geographic subdivisions and major geographic features. The project site is located in the Southern High Plains section, which is locally referred to as the Llano Estacado (Figure 19.3.3-3). As shown on Figure 19.3.3-3, the Llano Estacado is located to the north and east of the project site. The Llano Estacado is a high isolated pediment surface mesa that covers much of the Texas panhandle and eastern third of southeastern New Mexico. The Llano Estacado plateau occupies approximately 37,000 mi^2 (22 million ac.) (96,000 km^2 [9 million ha]). It is believed that the name refers to the palisade-like escarpment that surrounds the plain (Nicholson and Clebsch, 1961). Mescalero Ridge marks the edge of the Llano Estacado part of the High Plains section on the north. In southern Lea County, Mescalero Ridge is an irregular erosional topographic feature with a relief of about 30 ft. to 50 ft. (9.1 m to 15.2 m) compared with a nearly vertical cliff and relief of approximately 150 ft. (45.7 m) in Northwestern Lea County (IIFP, 2009).

The only native trees that grow in the Llano Estacado plateau are the shinoak and mesquite. The llano slopes gently to the southeast by 8 ft. to 10 ft. (2.4 m to 3.1 m) per mile. Approximately 34,000 shallow depressions, called playas, provide the only changes in elevation in the plateau. The Llana Estacado is the largest, isolated non-mountainous geological area in North America and home to many endemic plants and animals. South of the Portales Valley, the caliche caprock of the Ogallala Formation is generally near the surface; elsewhere, it is buried by sand and clay deposits. Surface drainage on the Southern High Plains (Llano Estacado) is poor, with larger regional drainages evident along the northwest to southeast lineaments (IIFP, 2009).

As shown on Figure 19.3.3-2, the project site is located in the Grama Ridge area. The Grama Ridge Area is topographically higher than the Querecho Plains–Laguna Valley area to the north and is marked on its southern end by a southwestward-facing scarp called Grama Ridge. The Grama Ridge area is characterized by a hard caliche surface whose topographic texture is similar to that of the High Plains. The surface is spotted with many shallow depressions. There is no integrated drainage, but the depressions are cut by well-incised gullies (Nicholson and Clebsch, 1961).

The regional slope is to the southeast, and wherever drainage patterns have developed they are consequent to the slope. Monument Draw, located immediately west of the project site, is the only major drainage feature within southern Lea County. The north to south drainage course of Monument Draw is almost perpendicular to the regional topography and drainage and conforms to the general trend only in its uppermost reaches. Farther east, in Texas, the regional slope is also east and southeast. In some places along its east side, the draw has some well-developed tributary drainage areas several miles long (Nicholson and Clebsch, 1961).

East of Monument Draw, the Eunice Plain rises toward a north-trending topographic high, known locally as Rattlesnake Ridge (Figure 19.3.3-2). Throughout most of its length, the crest of this ridge closely parallels the state line. Rattlesnake Ridge restricts Monument Draw to its north–south trend and is regarded as the drainage divide between the Pecos River basin and the Colorado River basin in Texas (Nicholson and Clebsch, 1961).

All stream courses in the project vicinity are ephemeral, and only one, Monument Draw, is located near the project site (Figure 19.3.3-2). Monument Draw traverses just west of the project site from north to south and extends into Texas (Nicholson and Clebsch, 1961).

19.3.3.1.2 Geologic Structure

The EIPC is located over the north-central portion of a subsurface structural feature known as the Central Basin Platform (Figure 19.3.3-4) (NUREG-2239). The Central Basin Platform is part of the larger Permian Basin and is composed of carbonate reef deposits and shallow marine clastic deposits. The Central Basin Platform extends northwest to southeast from southeastern New Mexico to eastern Pecos County, TX, and is a tectonically uplifted basement block capped by a carbonate platform. The Central Basin Platform is surrounded on three sides by regional structural depressions known as the Delaware Basin to the southwest, the Midland Basin to the northeast, and the Val Verde Basin to the south (NUREG-2239).

The Permian Basin, a large subsurface structural feature, underlies a large part of western Texas and southeastern New Mexico. Figure 19.3.3-4 shows the major structural elements of the Permian Basin in western Texas and regions of New Mexico where the EIPC is located. The Central Basin Platform is a steeply fault-bounded uplift of basement rocks that forms an abrupt eastern terminus of the Delaware Basin (NUREG-2239).

The Red Bed Ridge denotes the position of a drainage divide that has separated two major fluvial systems throughout the late Cenozoic Era. The area was uplifted at the start of the Laramide Orogeny when the Cretaceous seas retreated. From the late Paleocene to near the end of the Pliocene, the area was subjected to erosion, removing most of the Cretaceous deposits. The relatively resistant limestones over the partially silicified (i.e., silica-rich) Cretaceous Antlers Formation on the crest of the ridge may have effectively capped the Red Bed Ridge, maintaining the ridge as a mesa or inter-drainage high. The axis of the Red Bed Ridge runs long with a local topographic high between Monument Draw in Texas, which drains to the Colorado River, and Monument Draw in New Mexico, which drains to the Pecos River (NUREG-2239).

19.3.3.1.3 Stratigraphy

The stratigraphic sequence of the Central Basin Platform of the western Texas Permian Basin is shown in Figure 19.3.3-5.

Regions of western Texas and southeastern New Mexico experienced mild structural deformation that produced broad regional arches and shallow depressions during the Cambrian Period to late Mississippian Period. During the Mississippian and Pennsylvanian Periods, the Central Basin Platform uplifted, and the Delaware, Midland, and Val Verde Basins began to subside, forming separate basins. Also, Late Mississippian Period tectonic events uplifted and folded the Central Basin Platform. This uplift was followed by more intense late Pennsylvanian Period and early Permian Period deformation that compressed and faulted the area. The Late Paleozoic Era deformation was followed by a long period of gradual subsidence and erosion

that stripped the Central Basin Platform and other structures to near base-level, forming the Permian Basin. Accumulating along the edges and flanks of the regional structures were layers of arkose, sand, chert pebble conglomerate, and shale deposits as the expanding sea gradually rose over the broad eroded surfaces and truncated edges of previously deposited sedimentary strata (NUREG-2239).

Throughout the remainder of the Permian Period, the Permian Basin slowly filled with several thousand feet of evaporites, carbonates, and shales. During the Triassic Period, the area was once again slowly uplifted and eroded, eventually forming a large landlocked basin where deposits of the Dockum Group accumulated in alluvial floodplains and as deltaic (i.e., delta) and lacustrine (i.e., lake) deposits. During the Jurassic Period, the area was again subject to erosion. During the Cretaceous Period, a thick sequence of Cretaceous rocks was deposited over most of the area. The Cretaceous sequence of sediments was composed of a basal clastic unit (the Trinity, Antlers, or Paluxy sands) and overlying shallow marine carbonates. Uplift from the western and southward- and eastward-retreating Cretaceous seas occurred along with the Laramide Orogeny, which formed the Cordilleran Range west of the Permian Basin (NUREG-2239).

Sediments for the nearby Late Tertiary Period Ogallala Formation came from the uplifted land associated with the Laramide Orogeny. The major episode of Laramide folding and faulting occurred in the late Paleocene Epoch; however, there have been no major tectonic events in the area since the Laramide Orogeny (NUREG-2239).

19.3.3.2 On-site or Near-Site Geotechnical Investigations

Geologic formations of interest underlying the project site are expected to be similar to those at two nearby project locations. These project locations are the URENCO uranium enrichment facility in Lea County, NM, and the CISF project location proposed by WCS in Andrews County, TX. The URENCO facility is located approximately 1.3 mi. (2.1 km) northeast of the project site; the CISF site is 3.0 mi. (4.8 km) from the project site. Geotechnical investigation results from these two nearby sites are considered representative of geologic setting, stratigraphy, and soil conditions at the EIPC project site.

19.3.3.3 Site Geology

The geologic map of the area surrounding the project site is depicted in Figure 19.3.3-6. Surficial geology is dominated by sedimentary formations of the Quaternary Period. Those underlying the project site are eolian and piedmont deposits of the Holocene to middle Pleistocene Epochs. These formations are interlayered eolian sands and piedmont-slope sediments that are widespread deposits along the eastern flank of the Pecos River Valley, primarily between Roswell and Carlsbad. They are typically capped by thin eolian deposits. Alluvial deposits are represented immediately to the west of the project site in conjunction with the Monument Draw area (Sholle, 2003).

Geologic formations of interest at the EIPC project site from oldest to youngest (i.e., from deepest to most shallow) include the Triassic Age Dockum Group, the undifferentiated Ogallala/Antlers/Gatuña Formation, the Pleistocene Age Blackwater Draw Formation, and the Holocene Epoch windblown sands and playa deposits, as well as caprock caliche (Figure 19.3.3-5). The Dockum Group consists of clays, shales, siltstones, sandstones, and conglomerates. Five formations together form the Dockum Group, of which the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations are present beneath the project area. The

Santa Rosa Formation sandstone at the base of the Dockum Group is approximately 250 ft. (76 m) thick, and the top of the formation is approximately 1140 ft. (347 m) below the ground surface (NUREG-2239).

Figure 19.3.3-7 contains information from borings conducted at the nearby CISF site. Geologic cross sections indicate that a veneer of sandy silt and sand from the Blackwater Draw are present at the surface. Topsoil consists of brown silty sand that contains sparse vegetation debris and roots. The Blackwater Draw consists of reddish brown sand of fine-to-very-fine grains with minor amounts of clay. Beneath the topsoil is a variable sequence of calcium carbonate-cemented caliche (i.e., the caprock caliche). *Caliche* is a shallow layer of soil or sediment in which the particles have been cemented together by the precipitation of mineral matter in their interstitial spaces (King, 2022). The caprock caliche forms the resistant beds along the western and eastern margins of the Southern High Plains. The caprock caliche thickness varies but can reach up to 12 ft. (3.7 m). Thin layers of sand overlay the caliche (NUREG-2239).

19.3.3.4 Soils

Two areas having different soil associations exist in Lea County, NM. They are divided by the Mescalero Ridge and include the southern High Plains and the southern Desertic Basins, Plains, and Mountains. Soil associations in the southern High Plains area include:

- Kimbrough
- Kimbrough-Lea
- Portales-Stegall-Lea
- Amarillo-Arvana
- Brownfield-Patricia-Tivoli

The associations generally consist of shallow-to-deep gravelly and loamy soils or deep sandy soils formed from windblown and water-deposited materials in the Quaternary and late Tertiary Periods. Soft or hard caliche is generally found below soils in the majority of this area (IIFP, 2009).

Table 19.3.3-1 summarizes the characteristics of the primary soils in the Southern High Plains area in Lea County, NM, in which the EIPC project site is located. The table provides a description of the soil series, total depth, permeability, salinity, degree of limitation for the filter field, and shrink/swell potential.

A review of soils information for the project site indicates that three primary soil map units are present on the site, as illustrated on Figure 19.3.3-8 and summarized in Table 19.3.3-2. These include the Brownfield-Springer association (consisting of Brownfield and Springer soils), Gomez, and Kermit soils. The Brownfield-Springer association and the Gomez series are classified as farmland of statewide importance.

The Brownfield series consists of very deep, well drained, moderately permeable soils derived from sandy eolian deposits from the Blackwater Draw Formation of the Pleistocene Age. Brownfield soils are on plains that range from nearly level to gently sloping. Slope ranges from 0 to 5 percent. These soils are intermittently moist in September – November and March – June (USDA, 2022a).

The Springer series consists of very deep, well drained, moderately rapidly permeable soils that formed in eolian sediments and alluvium. These soils range from nearly level to hummocky, and they are on interdunes and dunes of sand sheets on stream terraces and alluvial plains. Slope ranges from 0 to 10 percent. Mean annual precipitation is about 25 in. (635 millimeters) (USDA, 2022b).

The Gomez series consists of deep, well drained, moderately rapidly permeable soils. These soils formed in sandy and loamy calcareous eolian or fluvial sediments in the Blackwater Draw Formation of the Pleistocene Age. The soils are on plains that range from nearly level to gently sloping. Slope ranges from 0 to 3 percent. Parent material consists of sandy and loamy calcareous eolian or fluvial sediments of the Blackwater Draw Formation of the Pleistocene Age. The Gomez soils occur on concave plains in broad, shallow basins that range from nearly level to undulating (USDA, 2022c).

The Kermit series consists of very deep, excessively drained soils formed in eolian sands. Kermit soils are on sandy plains with slopes of 0 to 12 percent. Kermit soils are on upland plains, alluvial fans, and valley-side slopes that range from nearly level to undulating and hummocky. The soils formed in non-calcareous, deep, sandy material that has often been reworked by wind. Sand dunes, coppice mounds, and blowout areas are common surface features (USDA, 2022d).

The soil erodibility factor (K factor) indicates the susceptibility of a soil to sheet and rill erosion. The K factor can range from 0.02 to 0.69 and soils with higher values are more susceptible to erosion. The Brownfield-Springer association and Kermit series both have a low erodibility factor (0.02). The Gomez series has a low-moderate erodibility factor (0.17) (NRCS, 2022). There are no erosion control and run-off best management practices currently in use as the site is currently undeveloped.

19.3.3.5 Seismology

The proposed project site near Eunice, NM, is in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the project site is low (IIFP, 2009).

The majority of earthquakes in the United States occur in the tectonically active western portion of the country; however, New Mexico can also experience earthquakes, although at a lower rate of occurrence and at lower intensities. Earthquakes in the area around the proposed project site include isolated and small clusters of low-to-moderate size toward the Rio Grande Valley of New Mexico and in Texas, southeast of the project site (IIFP, 2009).

Recorded earthquakes from 1950 through November 2022 in the approximately 100 mi. (161 km) region surrounding the project site are depicted in Figure 19.3.3-9. The figure also identifies the relative date the earthquakes occurred and the U.S. Hazard which identifies the probability of damaging shaking to occur. Earthquakes are superimposed on the 2014 National Seismic Hazard Map. Most of the earthquakes shown have had low-to-moderate magnitudes (magnitudes between 2.5 and 5.0). The largest recorded event within 100 miles (161 km) from 1950 through November 2022 was a moment magnitude 5.4 event located in Coalson Draw, TX, approximately 25 mi. (40 km) west of Mentone, TX. The two closest events to the project site included a body wave magnitude (mb) 3.3 event in 2001 that occurred 6.8 mi. (11 km) south of Eunice and 4.6 mb event in 1992 that occurred 7.5 mi. (12 km) south-southeast of Eunice.

Table 19.3.3-3 summarizes the earthquakes within an approximately 100-mi. (161-km) area surrounding the project site with a magnitude of 4.0 or greater (light magnitude) between 1950 and 2022. In total, 43 events of this magnitude were recorded during this period. A total of twelve events were recorded with magnitudes of 4.5 or greater.

The closest Quaternary Age faults are associated with the southwestern base of the Guadalupe Mountains; as such, they are distant from the project site. The closest such fault is unnamed, No. 907, located at the base of the Guadalupe Mountains, which is located in Guadalupe Mountains National Park in Culberson County, TX, approximately 109 mi. (175 km) from the project site. This is a normal fault with the most recent deformation estimated at less than 1.6 million years ago. A second fault associated with this region is Guadalupe Fault No. 2058, in Chaves and Otero Counties, NM; this fault is interpreted to have been active in the last 15,000 years (Machette and Jochems, 2015). Additional Quaternary Age faults are located south of the two previously mentioned faults along the southwestern base of the Guadalupe Mountains in Texas. The next closest area of Quaternary Age faulting is the Alamogordo Fault, which is divided into three sections. The sections of the Alamogordo Fault closest to the project site are located west in Otero County, NM, with the most recent deformation estimated at less than 130,000 years ago (NUREG-2239).

The 2023 USGS National Seismic Hazard Model, available via the USGS Earthquake Hazard Toolbox, is used to determine the site Uniform Hazard Response Spectra (UHRS) for a site classification C with 10,000-year return period and 1000-year return period (USGS, 2025). The horizontal Design Response Spectrum (DRS) is determined using the 10,000-year and 1000-year return period UHRS. The Peak Ground Acceleration of the horizontal DRS is 0.094 g, where g is the acceleration due to gravity of 9.8 meters per second squared (32.2 feet per second squared).

19.3.3.6 Other Hazards

19.3.3.6.1 Tsunamis

The EIPC project site is remote from any large body of water; furthermore, no recorded tsunamis have been reported in the vicinity surrounding the project site (NCEI, 2022g). There is therefore no threat to the EIPC from tsunamis.

19.3.3.6.2 Volcanism

Volcanos recorded in New Mexico and western Texas by the NCEI (2022g) include the Red Hill and Zuni-Bandara volcanos in western New Mexico and the Carrizozo volcano southeast of Albuquerque. The massive Carrizozo lava flow, which traveled 75 km (47 mi.) down the Tularosa Basin of south-central New Mexico, is one of Earth’s longest known Holocene Epoch lava flows. The flow originated from a broad, low basaltic shield on the floor of the Tularosa Basin, east of the Rio Grande Rift and topped by Little Black Peak, a small cinder cone. The flow was inferred to have been emplaced during a single long-duration eruption estimated to have lasted two-to-three decades. A surface exposure age of about 5200 years before present was obtained for the Carrizozo lava flow, the second youngest in New Mexico (Smithsonian Institution, 2022). The Carrizozo volcano is located approximately 189.9 mi. (305.6 km) northwest of the project site.

Because no active volcanos or any that have demonstrated recent activity exist in the vicinity of the project site, volcanos pose no threat to the EIPC.

19.3.3.6.3 Slope Stability

The terrain of the project site and the surrounding area is relatively flat with no portion sufficiently sloped to permit a landslide. The nearest recorded landslide is one that occurred east of Carlsbad but outside Lea County. No reported landslides are recorded for Lea County or nearby areas of Texas; therefore, there is no threat to the EIPC from slope instability.

19.3.3.6.4 Karst

A karst area is one generally characterized by numerous caves, sinkholes, springs, and little surface drainage. The Guadalupe Mountains contain many caves, but few of the features are traditionally used to define karst. The caves of the Guadalupe Mountains predate the large canyons and well-defined surface features seen today. Because the development of the caves is much older than the surrounding landscape, there are few typical karst features found when caves and the landscape develop simultaneously. The caves of the Guadalupe Mountains (including Carlsbad Caverns) were formed in a much different way than typical karst-forming processes, which is based on dissolution of the rock by rainwater. Between 4 million and 6 million years ago, waters rich in H_2S formed sulfuric acid (H_2SO_4), which dissolved the limestone along fractures and folds in the rock to form Carlsbad Cavern (NPS, 2022b).

Where such carbonate rocks are present at or near the surface in humid regions, units are typically karstified and contain varying densities of sinkholes, caves, and other karst features. The project site is located in a region that lacks carbonate rocks at or near the land surface (Weary and Doctor, 2014); however, evaporite basins in the subsurface (including Lea County) contain soluble rocks buried to depths of as much as 7000 ft. (2134 m), but generally much less. Because of the physical properties and high solubility of evaporite rocks (salt and anhydrites), human activities, such as fluid injection or leakage from well casings, can induce the formation of large solution voids. Collapses of these voids are known to propagate to the surface from depths of more than 1000 ft. (305 m) (Weary and Doctor, 2014).

Considering the data, there is no identified risk from karst associated with the dissolution of surface carbonate formations, but there is a minor potential for risk associated with deeper evaporative rock formations, as described below.

19.3.3.6.5 Subsidence

Oil and gas exploration and production have been occurring in Lea County, NM, since the 1920s in areas that have included Hobbs, Eunice, Jal, and other areas (Winchester, 1931). As illustrated in Figure 19.3.1-3, several existing oil wells (identified as oil pads on the aerial photograph) are present to the south and west of the project site.

Thousands of wells have been drilled through evaporite formations to find oil and gas. Because of the extent of the evaporites (salt and anhydrite), drilling and completion operations must be conducted in a manner that prevents the dissolution of the salt and protects the well during drilling and throughout the productive lives of the wells. There are several examples in the Permian Basin of catastrophic subsidence as a result of suspected oil field casing corrosion and dissolution of salt. The examples of subsidence associated with oil and gas operations include Wink Sinks I and II near Wink, TX, and the Jal Sink south of Eunice, NM. Wink Sink I developed in 1980, and Wink Sink II occurred in 2002. The Jal Sink developed in 2001; it is located about 8 mi. (12.9 km) northwest of Jal, NM. The geologic settings of Wink Sinks I and II and the Jal Sink are similar, as they occurred at the basin margin above the Capitan Reef. Although the exact

cause of development of these sinkholes is unknown, it is suspected that casing failure allowed unsaturated water to contact and subsequently dissolve the salt layers. It is unknown whether sinkhole development was enhanced by the upward movement of water from the Capitan Reef. Rising heads could have occurred in the Capitan Reef because of lower oilfield demand for water in the 1980s and 1990s, but there is no definitive evidence that the reef was involved. Overall, cementing of casings in oil and gas wells that penetrate salt sections is often problematic, and there is no general rule on addressing such problems (AECOM, 2012).

Because the characteristics of existing wells (e.g., well casing integrity) adjacent to and near the project site are unknown, there is some minor potential for risk to the EIPC associated with the dissolution of deeper evaporative rock formations.

Table 19.3.3-1
Summary of Characteristics of Primary Soils in Southern High Plains Area in Lea County, New Mexico

Soil Series	Description	Total Depth (in.)	Permeability (in/hr)	Salinity (mmhos/cm)	Degree of Limitation for Filter Field	Shrink/ Swell Potential
Amarillo	Sandy clay loam, chalky loam	60	0.63 to 2.0	0 to 1	Slight to moderate: permeability	Low to moderate
Arvana	Sandy clay loam	28	0.63 to 2.0	0 to 1	Severe: indurated caliche at shallow depth	Moderate
Brownfield	Fine sand, sandy clay	63	0.63 to 6.3	0 to 1	-	Low to moderate
Kimbrough	Gravelly loam	6	0.63 to 2.0	0 to 2	Severe: indurated caliche at shallow depth	Low
Lea	Loam	26	0.63 to 2.0	0 to 2	Severe: indurated caliche at shallow depth	Moderate
Patricia	Fine sand, sandy clay	70	0.63 to 20.0	0 to 1	Slight to moderate: permeability	Low to Moderate
Portales	Loam and clay loam	60	0.63 to 2.0	0 to 2	Slight to moderate: permeability	Moderate
Stegall	Clay loam	28	0.06 to 0.2	0 to 4	Severe: indurated caliche at shallow depth; low permeability	High
Tivoli	Fine sand	60	0.63 to 20.0	0 to 1	Slight to moderate: possible contamination of water; 0 to 12% slope	Low

Source: IIFP, 2009
Abbreviations: in. = inch(es) | hr. = hour(s) | mmhos/cm = millimhos per centimeter

Table 19.3.3-2
Characterization of Soils on the Project Area

Map Unit Symbol	Map Unit Name	Prime Farmland Designation	Hydric Soil Designation	Area (ac.)
BO	Brownfield-Springer association	Farmland of statewide importance	Non-hydric	127.7
GM	Gomez loamy fine sand, dry, 0-to-3% slopes	Farmland of statewide importance	Non-hydric	116.1
KM	Kermit soils and Dune land, 0-to-12%slopes	Not prime farmland	Non-hydric	1.7
			Total	**245.6**

Note: Total may add up to more or less than 100 percent due to rounding.
Abbreviations: ac. = acre(s)

Table 19.3.3-3
(Sheet 1 of 2)
Recorded Earthquakes (Magnitude of 4.0 or Greater) from 1950 to 2022

Year	Latitude	Longitude	Depth (km)	Magnitude	Location
1975	31.425	-104.012	5.0	4.8	24 km WNW of Toyah, TX
1992	32.336	-103.101	5.0	4.6	12 km SSE of Eunice, NM
1999	32.591	-104.630	1.0	4	26 km SSE of Hope, NM
2004	32.525	-104.566	5.0	4	31 km SSW of Atoka, NM
2005	32.528	-104.549	5.0	4.1	30 km SSW of Atoka, NM
2010	32.438	-104.501	4.0	4.1	25 km W of Carlsbad, NM
2010	32.524	-104.607	5.0	4	33 km SSE of Hope, NM
2020	31.717	-104.042	9.5	5	41 km W of Mentone, TX
2020	32.295	-101.794	5.0	4	18 km N of Stanton, TX
2021	31.654	-101.774	6.2	4.5	57 km S of Whites City, NM
2021	31.663	-104.357	7.4	4	56 km S of Whites City, NM
2021	31.664	-104.030	6.1	4.4	56 km S of Whites City, NM
2021	32.071	-104.371	7.8	4	37 km ESE of Malaga, NM
2021	31.609	-104.003	6.3	4.3	54 km NW of Toyah, TX
2021	31.665	-104.258	6.8	4.3	56 km S of Whites City, NM
2021	31.672	-104.313	6.1	4.3	55 km S of Whites City, NM
2021	31.597	-104.400	7.3	4.1	36 km NNW of Toyah, TX
2021	31.593	-104.377	8.8	4.3	36 km NNW of Toyah, TX
2021	31.673	-104.380	6.1	4.2	55 km S of Whites City, NM
2021	31.706	-104.001	8.1	4	40 km W of Mentone, TX
2021	31.722	-104.370	7.3	4	52 km SSW of Whites City, NM
2021	31.565	-104.024	8.5	4.4	35 km NW of Toyah, TX
2021	32.286	-104.517	8.4	4.6	17 km N of Stanton, TX

Table 19.3.3-3
(Sheet 2 of 2)
Recorded Earthquakes (Magnitude of 4.0 or Greater) from 1950 to 2022

Year	Latitude	Longitude	Depth (km)	Magnitude	Location
2022	31.674	-103.719	7.4	4.2	55 km S of Whites City, NM
2022	31.660	-104.420	7.4	4.3	57 km S of Whites City, NM
2022	31.586	-104.385	6.2	4	65 km NNE of Van Horn, TX
2022	31.669	-104.567	6.8	4.6	56 km S of Whites City, NM
2022	31.614	-103.977	9.3	4	37 km WSW of Mentone, TX
2022	31.615	-103.971	8.8	4	36 km WSW of Mentone, TX
2022	31.600	-103.982	9.6	4.3	western Texas
2022	31.715	-104.551	6.2	4.6	53 km SSW of Whites City, NM
2022	31.719	-104.539	5.3	4.3	52 km SSW of Whites City, NM
2022	31.658	-104.518	7.5	4.1	58 km SSW of Whites City, NM
2022	31.680	-104.421	5.9	4.9	55 km S of Whites City, NM
2022	31.674	-104.383	7.2	4.2	55 km S of Whites City, NM
2022	31.683	-104.425	6.6	4.5	54 km S of Whites City, NM
2022	31.625	-103.989	6.6	4.4	38 km WSW of Mentone, TX
2022	31.592	-104.002	6.2	4.1	36 km NNW of Toyah, TX
2022	31.637	-103.999	6.9	5.4	Coalson Draw, TX
2022	31.629	-104.009	8.1	4	39 km WSW of Mentone, TX
2022	31.635	-104.002	7.5	4	38 km WSW of Mentone, TX
2022	31.634	-103.988	7.4	4.5	western Texas
2022	31.627	-104.003	8.5	4.7	34 km WSW of Mentone, TX

Source: USGS, 2022b
Abbreviations: km = kilometer(s) | WNW = west-northwest | TX = Texas |SSE = south-southeast | NM = New Mexico | SSW = south-southwest | W = west | N = north | S = south | ESE= east-southeast | NW = northwest | NNW = north-northwest | NNE = north-northeast | WSW = west-southwest

19.3.4 WATER RESOURCES

19.3.4.1 Hydrology

19.3.4.1.1 Surface Water

The proposed project site is within the Hydrologic Unit Code (HUC) 12 – 130700070206 sub-watershed, which is part of the Lower Pecos subregion (Figure 19.3.4-1). The nearest river to the project site is the Pecos River, located about 75 mi. (121 km) to the west of Eunice, NM, near Carlsbad, NM, per a biological desktop review prepared for the site. Surface water in the vicinity of the project site, and in surrounding Lea County, is limited to unnamed intermittent streams and small playa lakes that result from heavy monsoon rainfall events (LCWUA, 2000).

Within the project site boundary and within the off-site utility corridor, no permanent surface water features are present. Stormwater drainage from the project site generally flows to the southwest, as identified in the Phase I Environmental Site Assessment (prepared by NV5 in 2020).

The project site is not located within or near any floodplains and is not located within a special flood hazard area.

19.3.4.1.1.1 Watershed Description

The proposed project site is located within the Landreth-Monument Draw watershed (Figure 19.3.4-1). This watershed covers a total of 4,057,150 ac. (16,419 km^2) across Texas and New Mexico (NRCS, 2002). The main surface water feature within a 5-mi. (8-km) radius of the project site is Monument Draw, an intermittent stream located to the southwest of the project site (Figure 19.3.4-2). Additionally, draws, drainage areas, and surface depressions in the vicinity are ephemeral and may seasonally contain water for short durations following precipitation events, though they would dry out quickly due to evapotranspiration and infiltration. Surface water features in the vicinity generally occur in response to precipitation events (NUREG-2239). Based on a review of the National Hydrography Dataset (NHD) and the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) for potential Waters of the United States conducted for the biological desktop study, wetlands are not located within the project site or within the off-site utility corridor. Approximately 31.2 ac. (0.13 km^2) of NWI emergent wetlands and 95.7 ac. (0.39 km^2) of NWI scrub/shrub wetlands are mapped within the vicinity of the project site (Figure 19.3.4-2)(USFWS, 2022a).

No large-scale surface water bodies or through-flowing drainage systems occur in the Pecos River Basin (LCWUA, 2000).

19.3.4.1.1.2 Streams and Ponds

No permanent surface water bodies (streams, lakes, or ponds) or drainage features occur within the project site or within the off-site utility corridor, per the Phase I Environmental Site Assessment (prepared by NV5 in 2020). Local surface water features in the vicinity of the project site include Monument Draw, Baker Spring, and several ponds on nearby industrial properties, as described in NUREG-1790. A total of 60.9 ac. (0.25 km^2) of open water is present within a 5-mi. (8-km) radius of the project site, consisting primarily of manmade ponds and impoundments. There are no operational USGS) stream gages in Lea County.

Only one named drainage feature, Monument Draw, is located near the project site; it consists of approximately 6.6 mi. (10.6 km) of noncontinuous streambed within the project vicinity (Figure 19.3.4-2). Although Monument Draw is typically dry, a maximum historical flow of 1280 cubic feet per second (36.2 cubic meters per second) occurred on June 10, 1972 (NUREG-1790); however, there is no direct outfall to Monument Draw from the project site. Stormwater drainage from the off-site utility corridor may result in small-scale outfall to Monument Draw. Surface water is present intermittently in Baker Spring, which is located northeast of the project site (Figure 19.3.4-2). Baker Spring surface water is impounded and localized when present, and surface water is attributed to seepage and/or precipitation and runoff (NUREG-1790).

Other surface water features in the vicinity of the project site are limited to intermittent streams and small ephemeral playa lakes that result from heavy rainfall each year during May through October, when 80 percent of annual rainfall occurs (indicated as open water on Figure 19.3.4-2). Water for livestock is the primary use of these intermittent surface water sources (NMISC, 2016).

19.3.4.1.1.3 Dams, Reservoirs, and Impoundments

The project site does not include any freshwater lakes or ponds. No reservoirs or impoundments are present within the project site or vicinity.

19.3.4.1.1.4 Estuaries and Oceans

No estuaries or oceans are located near the project site.

19.3.4.1.2 Groundwater

Groundwater resources in the vicinity of the site include the Pecos River Basin Alluvial Aquifer, the High Plains Aquifer (Ogallala Formation), the Santa Rosa Aquifer (Dockum Group Formation), and the Rustler Formation. Details on each of these groundwater sources are presented in Table 19.3.4-1. The northern edge of the Pecos River Basin Alluvial Aquifer, which consists of alluvial deposits from the Pecos River Basin, is located near the project site. This aquifer is unconfined and, in some areas, not continuous. This aquifer consists of saturated alluvial and aeolian deposits along stream beds (NMISC, 2016). The Rustler Formation underlies all of Lea County (including the project site) and produces brackish-to-saline water (NMISC, 2016). The majority of this formation is composed of evaporite beds, which have a low permeability and manifest water-quality limitations for potable or agricultural uses. A hydrostratigraphic cross section in Figure 19.3.4-3 illustrates the relationship between the Dockum Group and High Plains Aquifer in this region. Additionally, localized shallow groundwater can occur within the vicinity. Groundwater volume in these areas is limited, and recharge is attributed to infiltration from substantial surface depressions that collect surface water runoff (NUREG-1790).

19.3.4.1.2.1 High Plains Aquifer (Ogallala Formation)

As illustrated in Figure 19.3.4-4, the project site is located near the southern edge of the High Plains Aquifer (also known as the Ogallala Aquifer), which is part of the Ogallala Formation in New Mexico. The High Plains Aquifer contains approximately 3.3 billion acre-feet (ac-ft) (4 trillion m^3) of water and is the largest groundwater system in North America. The aquifer is located primarily under the High Plains from west of the Mississippi River to the Rocky Mountains. The aquifer system underlies 174,000 mi^2 (451,000 km^2) of land and extends under

portions of at least eight states: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming (NUREG-1790). An estimated 200 million ac-ft (247 billion m^3) of saturated material exists in the High Plains Aquifer in New Mexico, with an estimated 3590 mi^2 (9298 km^2) of High Plains Aquifer area that contains little or no saturated thickness (McGuire et al., 2012).

In Lea County, only 0.25 in. to 0.5 in. (0.64 cm to 1.27 cm) of precipitation each year infiltrates and recharges the High Plains Aquifer (Musharrafieh and Chudnoff, 1999). Estimates of recharge to the High Plains Aquifer in Lea County, NM, range between 37,500 ac-ft/yr and 75,000 ac-ft/yr (46.5 million m^3/yr to 92.5 million m^3/yr) (LCWUA, 2000). Historically, the High Plains Aquifer flowed to the southeast, with a gradient of 15.0 ft/mi to 15.8 ft/mi (2.8 m/km to 3.0 m/km). Intensive pumping and water removal from the aquifer in New Mexico and Texas have resulted in overall declines in water level and a shift in groundwater flow. A more recent evaluation of flow indicates flow to the southeast at a gradient of about 13 ft/mi to 13.7 ft/mi (2.5 m/km to 2.6 m/km) (LCWUA, 2000; NMISC, 2016). Specific yield, or the volume of water that can be drained by gravity from the saturated sediments per unit drop in the water table, in Lea County ranges from 10 percent to 28 percent (Musharrafieh and Chudnoff, 1999; LCWUA, 2000).

19.3.4.1.2.2 Groundwater Decline

Saturated thickness of those aquifers present in Lea County, NM, can be found in Table 19.3.4-1. In New Mexico, the average water level in the High Plains Aquifer decreased by 16.5 ft. (5.0 m) between 1950 (predevelopment) and 2015 (McGuire, 2017). In Lea County, High Plains Aquifer groundwater level declines of 50 ft. to 100 ft. (15 m to 30 m) have been reported over this same time period (pre-1950 to present) as a result of intensive groundwater withdrawals (McGuire, 2014; NMISC, 2016). The average rate of decline of High Plains Aquifer groundwater levels in Lea County is 0.59 ft/yr (0.18 m/yr) (NMISC, 2016). Estimates of aquifer drawdown along the Texas border indicate that water levels have declined in excess of 60 ft. (18.3 m) and, in some localized areas, greater than 80 ft. (24.4 m) since 1940, largely as a result of pumping in Texas (LCWUA, 2000). Water table levels reported in 2007 for the High Plains Aquifer in Lea County are illustrated in Figure 19.3.4-5.

In the Santa Rosa Aquifer, declines in water level of up to 50 ft. (15 m) occurred from 1968 to 1998 in some areas within the aquifer, but increases in other areas of 10 ft. to 30 ft. (3 m to 9 m) were also seen over this time period (LCWUA, 2000).

In the Pecos River Basin Alluvial Aquifer, saturated thickness is substantial in some places but thin at most locations. Declines in water level have occurred in some areas of the aquifer as a result of groundwater pumping and evapotranspiration. Recharging of this aquifer is primarily linked to infiltration of surface water from surrounding uplands or ephemeral stream beds (LCWUA, 2000).

Nearby USGS monitoring wells, illustrated in Figure 19.3.4-6, are used to track groundwater levels in aquifers. The depth to water at the Pecos River Basin Alluvial Aquifer Well, approximately 6.2 mi. (10.0 km) from the project site, from 1965 to 2022 ranged from 60 ft. to 65 ft. (18 m to 20 m) (USGS, 2022c). The depth to water in the monitoring well at the Santa Rosa Sandstone Well (Santa Rosa Aquifer), located 2.7 mi. (4.3 km) from the project site, from 1953 to 2021 ranged from 129 ft. to 150 ft. (39 m to 46 m) (USGS, 2021a). Finally, the depth to water in the Ogallala Formation Well (High Plains Aquifer), located 10.0 mi. (16.1 km) from the project site, from 1953 to 2022 ranged from 204 ft. to 206 ft. (62 m to 63 m) (USGS, 2022d).

19.3.4.1.2.3 Local Groundwater Resources

Based on data from private wells within 1 mi. of the project site collected in the Phase I Environmental Site Assessment (prepared by NV5 in 2020), the depth to groundwater in the project vicinity ranges from 16 ft. to 241 ft. (4.8 m to 73.5 m). Data from these wells indicate that groundwater at the project site generally flows to the northwest. Localized, shallow groundwater exists within the vicinity of the project site, near the Wallach Concrete, Inc. and Sundance Services, Inc. properties to the northeast; however, this localized subsurface saturation is limited. This saturated zone is characterized by discontinuity and low permeability, suggesting that this groundwater is a perched water condition and not an aquifer (NUREG-1790).

Groundwater resources in Lea County, NM, are divided into five major distinct underground water basins (UWBs). These basins are illustrated on Figure 19.3.4-7 and include the following UWBs:

- Lea County UWB (2671.0 mi^2 [6917.9 km^2]).
- Roswell UWB (55.3 mi^2 [143.2 km^2]).
- Capitan UWB (1143.2 mi^2 [2960.9 km^2]).
- Carlsbad UWB (509.4 mi^2 [1319.3 km^2]).
- Jal UWB (approx. 14.6 mi^2 [37.8 km^2]).

As stated in Subsection 19.3.4.2.2, the Lea County UWB is the municipal water source for Eunice, NM. The Lea County UWB extends from east to west across Lea County and is bounded to the south by Mescalero Ridge (see Figure 19.3.3-2). The primary aquifer that supplies the Lea County UWB is the High Plains Aquifer; however, the aquifer is not present, or the saturated thickness is small, in some locations (NMISC, 2016). The average estimated annual recharge to the Lea County UWB is between 29,000 ac-ft and 58,000 ac-ft (35.8 million m^3 to 71.5 million m^3). Downward percolation from the High Plains (Ogallala) Aquifer is limited by Cretaceous Period and Triassic Period rocks underlying the Ogallala Formation.

The project site is within the limits of the Capitan UWB. The Capitan UWB occurs within dolomite and limestone strata that were deposited as an ancient reef formation (LCWUA, 2000). Within the Capitan UWB, isolated areas of saturated Ogallala Formation resources are approximately 50 ft. (15 m) thick; however, these areas are not formally included in the High Plains Aquifer.

In Texas, groundwater resources are divided into Groundwater Conservation Districts (GCDs). However, Andrews County, TX, does not have a formally defined GCD, and therefore there are no GCDs within the vicinity of the project site.

19.3.4.2 Water Use

19.3.4.2.1 Regional Surface Water Use

Surface water is limited to intermittent or ephemeral surface water resources, including intermittent streams, lakes, and small ephemeral playa lakes, used as water sources for livestock. Small, manmade earthen structures are used to collect surface runoff explicitly for this purpose (LCWUA, 2000). In 2010, a total of 75 ac-ft (92,511 m^3) of surface water was used as a

self-supplied water source for livestock (NMISC, 2016). There are no perennial surface water features within or near the project site.

19.3.4.2.2 Groundwater Use

There are no wells within the project site. A total of 51 wells exist within 1 mi. (1.6 km) of the project site, which consist of the following types:

- 26 active, 17 plugged, and two cancelled oil wells.
- Three active and two plugged gas wells.
- One saltwater disposal well.

Almost all the wells in the vicinity of the project site are to the south or west of the project site. No incidents or releases have been documented for any wells in the vicinity, per the Phase I Environmental Site Assessment (prepared by NV5 in 2020).

Water use in the vicinity of the project site is primarily limited to groundwater withdrawal. In Lea County, NM, primary uses of groundwater include irrigation and municipal water supply (NMISC, 2016). Lea County municipalities that withdraw groundwater from the High Plains Aquifer within the Lea County UWB include Eunice, Hobbs, Lovington, and Tatum to the north (LCWUA, 2000). Hobbs, Lovington, and Tatum are all located physically within the Lea County UWB (Figure 19.3.4-7). Eunice, however, is physically located in the Capitan UWB but withdraws water from the Lea County UWB from a well 18.5 mi. (24.7 km) from the project site, near Hobbs, NM. While Jal is physically located in the Capitan UWB, Jal withdraws water from the alluvial sediments in the Jal UWB. Water withdrawals within Lea County in 2010 and 2015 are presented in Table 19.3.4-2. Agricultural irrigation accounted for approximately 87 percent of water use in Lea County in 2010, while municipal use accounted for only 7 percent (NIMSC, 2016; Longworth et al., 2013).

Total water use from groundwater withdrawals in Lea County in 2015 was approximately 142,338 ac-ft (176 million m^3) (Magnuson et al., 2019), a decrease from the 2010 water use of approximately 197,024 ac-ft (243 million m^3) (Longworth et al., 2013; NMISC, 2016). Groundwater withdrawals in Lea County come from two of the five UWBs, the Lea County UWB and the Jal UWB. Groundwater levels in Lea County declined approximately 50 ft. to 100 ft. (15 m to 30 m) as a result of intensive groundwater pumping between predevelopment (about 1950) and 2013 (McGuire, 2014). Drawdown of the Jal UWB averages 1.4 ft/yr (0.43 m/yr) but has been observed to be as great as 6.6 ft/yr (2.0 m/yr). Due to the limited and diminishing groundwater supply in the Lea County and Jal UWBs, there is interest in development of appropriations for water withdrawal from the Capitan and Carlsbad UWBs (NMISC, 2016).

Water supply available to meet projected water demand in Lea County for 2060 was predicted using different methods; it is summarized in Table 19.3.4-3. The total projected water demand in Lea County by 2060, based upon a projected population growth rate of 0.36 percent to 0.98 percent, ranges from 185,125 ac-ft/yr to 208,490 ac-ft/yr (232 million m^3/yr to 258 million m^3/yr). Increases in demand are projected to be related to increases of 104 percent in self-supplied domestic supply and 68 percent in public water supply demands. Reductions in water demand of 10 percent for irrigated agriculture and 20 percent for self-supplied livestock are projected. The Lea County UWB is predicted to experience a drawdown of 29.5 ft. to 51.1 ft. (9 m to 15.6 m) by 2060, depending on the method of estimation and assumed levels of precipitation (NMISC, 2016).

The EIPC plans to obtain water, for both potable and industrial uses, from the Eunice public water supply system; as such, there are no plans for groundwater use at the project site.

19.3.4.2.3 Facility Water Use

Water use by the EIPC is described in Section 19.2.5. The EIPC receives its water supply from the Eunice Municipal Water Supply, which withdraws groundwater from the High Plains Aquifer. Expected total water withdrawals from the Eunice Public Water Supply by the EIPC is anticipated to be 20.2 million gallons (gal.)/yr (76.5 million liters (L)/yr). Total groundwater withdrawals by the Eunice Public Water Service in 2015 were approximately 1446 ac-ft (1,800,000 m^3) (Magnuson et al., 2019). The approximate per capita water use for Eunice is 351 gal. (1329 L) per capita per day (Magnuson et al., 2019). The total capacity for the Eunice Public Water Supply is 4.03 million gallons per day (gpd) (15.3 million L/day) with daily average usage of 1.47 million gpd (5.6 million L/day). Additionally, the Eunice Municipal Water Service provides part of the water used at URENCO's enrichment facility (Magnuson et al., 2019).

19.3.4.2.4 Applicable Regulations and Permits

Surface stormwater discharge is federally regulated under the Clean Water Act. Regulatory requirements for stormwater discharge have been established under the federal National Pollutant Discharge Elimination System (NPDES). This permitting requirement serves as a regulatory program for enforcement of water quality standards and effluent limitations. In New Mexico, point source discharge of stormwater from industrial or commercial facilities to state waters requires coverage under the NPDES General Permit for Industrial Stormwater.

State permitting for water management falls under the jurisdiction of the New Mexico Water Quality Act (New Mexico Statutes Annotated [NMSA], Chapter 74, Article 6), which establishes water quality standards and applies to permitting prior to construction and during operation, closure, post-closure, and abatement, if necessary. As required, permitting for monitoring wells installed and managed in accordance with the New Mexico Water Quality Act are required from the New Mexico Office of the State Engineer (NMOSE). Additionally, there may be permitting and compliance requirements associated with the New Mexico Groundwater Protection Act (NMSA, Chapter 74, Article 6B), which establishes standards for protection of groundwater from leaking underground storage tanks (NUREG-1790).

Groundwater quality in New Mexico is regulated under the New Mexico Water Quality Act in Title 20 of the New Mexico Administrative Code, Chapter 6.2. Under this statute, the New Mexico Environmental Department implemented groundwater quality standards that, in general, mirror federal drinking water standards. Groundwater is managed by the NMOSE, who has jurisdiction over groundwater within UWBs. Permits for use of groundwater are contingent upon water availability, potential impairment of other water rights, and the protection and conservation of public welfare in the state (LCWUA, 2000). Regulation of deep, non-potable aquifers is codified in NMSA 1978, §72-12-25 (2009), which provides for management of groundwater basins greater than 2500 ft. (762 m) deep and containing greater than 1000 ppm of total dissolved solids. The primary concern for management of these aquifers relates to the drilling of wells (NMISC, 2016).

19.3.4.2.5 Water Use Rights

Surface water within Lea County is limited to ephemeral streams, lakes, and playas that do not fall under the jurisdiction of the NMOSE, as they are not subject to appropriation for beneficial

use. Statutes in New Mexico dictate that all underground waters of the state belong to the public and are subject to appropriation for beneficial use (LCWUA, 2000). In December 2004, Active Water Resource Management regulations were enacted; it established a framework for distribution of water rights, compliance with stream compacts, and prevention of waste/promotion of conservation in regard to water. Regulations addressing domestic wells (or those for personal, potable water use) were amended in 2006 to include a withdrawal limit of 1.0 ac-ft/yr (1234 m^3) for drinking and sanitary purposes incidental to the operations of a governmental, commercial, or nonprofit facility so long as no other water source is available. The amount of water so permitted is subject to further limitations imposed by a court or a municipal or county ordinance. In 2009, the NMOSE closed the High Plains Aquifer within the Lea County UWB to applications for new water appropriations (NMISC, 2016).

Water use within the municipality of Eunice is regulated through the Code of Ordinances, Supplement 2, which includes provisions relating to water conservation of those waters supplied by the municipality. Prohibitions under this code include the wasting of water through excessive outdoor watering, watering of sidewalks or driveways, or allowing the escape of water through leaking plumbing. Water use restrictions are based on drought conditions and allow for water rationing if water shortage conditions could threaten public health (NMISC, 2016).

19.3.4.3 Water Quality

19.3.4.3.1 Surface Water Quality

Surface water resources in the vicinity of the project site are minimal and are limited to ephemeral or intermittent features; thus, active monitoring of surface water quality is not conducted. No surface water reaches in the vicinity of the project site (HUC 13070070206) are listed on the New Mexico 303(d) list of impaired waters.

19.3.4.3.2 Groundwater Quality

Activities in Lea County that are commonly associated with groundwater contamination include the following (LCWUA, 2000):

- Petroleum production facilities.
- Agricultural activities.
- Wastewater disposal systems.
- Underground storage tanks.
- Mines and quarries.
- Industrial facilities.
- Landfills.
- Livestock industry activities.
- Radioactive mineralization.

Groundwater in the High Plains (Ogallala) Aquifer and Pecos River Basin Alluvial Aquifer, while exhibiting high levels of hardness, is consistently of good quality and used for a variety of activities, including public water supply and irrigation (LCWUA, 2000). Results of water quality monitoring performed in 2000 for the public water supplies in the municipalities of Hobbs and

Eunice, NM, are summarized in Table 19.3.4-4. All parameters for the monitored public water supply sampling were less than the maximum contaminant level established by the USEPA.

Table 19.3.4-5 provides groundwater quality monitoring data from the closest USGS monitoring well that records water quality data, which is located in Andrews County, TX (USGS, 2022e), 8.9 mi. (14.3 km) from the project site. In general, groundwater quality remained consistent from 2012 to 2021. Significant decreases in total dissolved solids, nitrate, sodium, fluoride, and sulfate were observed from 2012 to 2021, indicating an improvement in water quality. Alkalinity, conductance, and hardness remained relatively stable from 2012 to 2021.

Table 19.3.4-1
Primary Groundwater Aquifers in Central Lea County within the Project Site Vicinity

Primary Aquifer[a]	Associated Geologic Formation	Depth to Water	Slope Direction	Potentiometric Surface Elevation (AMSL)	Saturated Thickness	Water Use
Pecos River Basin Alluvial Aquifer	Quaternary Alluvium	50 ft. – 100 ft.	Not reported	Not reported	> 500 ft.	Limited domestic and livestock uses
High Plains Aquifer	Ogallala Formation	20 ft. – 250 ft.	Southeast at a gradient of 13 – 13.7 ft/mi	<3750 ft.[b]	Declining as a result of pumping drawdown; <200 ft.[c]	Domestic, agriculture, and industrial use; primary water source for all groundwater in Lea County, including public water supply
Santa Rosa Aquifer	Dockum Group	120 ft. – 700 ft.	Southwest	2820 ft. – 3400 ft.	Average: 200 ft. – 250 ft.; Maximum: 2400 ft.	Domestic and livestock uses in southern Lea County
Rustler Formation	Permian	240 ft. – 355 ft.	Southwest	2835 ft. – 2765 ft.	90 ft. – 450 ft.[d]	Limited primarily to livestock watering, brackish saline water

Source: LCWUA, 2000; McGuire et al., 2012, Rinehart and Mamer, 2017
a) Aquifers are presented in order of relative depth.
b) In the Ogallala Aquifer between Hobbs and Eunice, NM; 2010 model estimates.
c) Saturated thickness within Lea County, NM.
d) Formation thickness.
Abbreviations: AMSL = above mean sea level | ft. = feet | ft/mi = feet per mile

Table 19.3.4-2
Total Water Withdrawals in the Lea County Water Planning Region in 2010 and 2015

Water Use Category	2010 Withdrawals (ac-ft)			2015 Withdrawals (ac-ft)		
	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
Commercial (self-supplied)	0	1866	1866	0	1541	1541
Domestic (self-supplied)	0	1498	1498	0	1510	1510
Industrial (self-supplied)	0	270	270	0	1780	1780
Irrigated agriculture	0	172,297	172,297	0	117,366	117,366
Livestock (self-supplied)	75	2111	2186	43	2658	2702
Mining (self-supplied)	0	2006	2006	0	1603	1603
Power (self-supplied)	0	3781	3781	0	4472	4472
Public water supply	0	13,195	13,195	0	11,407	11,407
Reservoir evaporation	0	0	0	0	0	0
Total	75	197,024	197,099	43	142,338	142,381

Source: Longworth et al., 2013; NMISC, 2016; Magnuson et al., 2019
Abbreviations: ac-ft = acre-feet

Table 19.3.4-3
Predicted Water Supply in Lea County Underground Water Basin in 2060 by Method

Method	Lea County Underground Water Basin Supply (ac-ft/yr)	Percent of 2010 Demand Met
Model-Predicted Decline	143,700	74
Observed Rate of Decline	156,960	80
Drought Supply	128,860	66

Source: NMISC, 2016
Abbreviations: ac-ft = acre-feet | yr. = year(s)

Table 19.3.4-4
Groundwater Quality as Measured in Lea County Public Water Supply, 2000

Parameter	Units	Hobbs, NM	Eunice, NM	USEPA Maximum Contaminant Level
Alkalinity — Total	mg/L	163[a]	186.5	N/A
Specific Conductivity	µmhos/cm	839.9	716.8	N/A
Hardness	mg/L	293.3	248	N/A
pH	Standard Units	7.5	7.2	6.5 to 8.5
Turbidity	NTU	not detected	1.0	N/A
Total Dissolved Solids	mg/L	410.0	415.7	500[g]
Arsenic	mg/L	0.008	0.008[d]	0.050
Calcium	mg/L	80.7	80.5	N/A
Chloride	mg/L	114.0	63.4	250[g]
Fluoride	mg/L	1.1	1.0[e]	4.0
Iron	mg/L	0.05	<0.25[f]	0.3
Magnesium	mg/L	44.4	11.5	4.0
Mercury	mg/L	not detected	<0.0002[d]	N/A
Nitrate	mg/L	3.8	2.6	10
Potassium	mg/L	3.4[a]	4.8	
Sodium	mg/L	38.0	42.6	N/A
Sulfate	mg/L	113.1[b]	67.2	
Gross Alpha	pCi/L	3.1 ± 0.9 to 16.6 ± 2.9[c]	2.8 ± 1 to 6.6 ± 1[c]	15

Source: LCWUA, 2000
a) Sampled at entry point: August 23, 1994.
b) Sampled at entry point: February 1996.
c) Range in concentration, low and high; sampled from 1994 through 1997.
d) Sampled at entry point: March 1995.
e) Sampled at entry point: March 1996.
f) Samples taken from 1975 to 1979.
g) Results are either annual averages for all wells in a system at the entry point of a system or averages of all wells in a system for a particular sampling date.

Abbreviations: NM = New Mexico | USEPA = U.S. Environmental Protection Agency | mg/L = milligrams per liter | N/A = not applicable; maximum contaminant level not established | µmhos/cm = micromhos per centimeter | NTU = nephelometric turbidity units | pCi/L = picocuries per liter

Table 19.3.4-5
Groundwater Quality Measurement from Jumbo Hill Quad Monitoring Well, 2012 – 2021

Parameter	Units	2012	2016	2021
Alkalinity — Total	mg/L	182	193	190
Specific Conductivity	µS/cm	1515	1555	1247
Hardness	mg/L	582	523	429
pH	Standard Units	7.3	7.1	7.3
Temperature	°C	21.2	21.9	26.5
Total Dissolved Solids	mg/L	1177	882	737
Alpha Particle	pCi/l	<7.20	0.00	3.44
Aluminum	µg/L	<4.0	<4.0	<5.0
Arsenic	µg/L	4.7	4.68	3.34
Barium	µg/L	40.7	49.8	43.2
Bromide	mg/L	2.31	1.85	1.55
Calcium	mg/L	172	180	148
Chloride	mg/L	266	287	188
Chromium	µg/L	3.20	2.08	3.15
Fluoride	mg/L	1.13	0.26	0.24
Inorganic Nitrogen (Nitrate plus Nitrite)	mg/L	17.6	5.34	3.2
Iron	µg/L	<50.0	<50.0	<50.0
Lead	µg/L	<1.00	<1.00	<1.00
Magnesium	mg/L	36.5	17.6	14.3
Mercury	µg/L	<0.2	<0.2	<0.2
Nitrate	mg/L	77.92	1.51	14.17
Phosphorus	mg/L	<0.02	<0.02	<0.02
Potassium	mg/L	8.03	4.05	3.99
Silica	mg/L	54.4	57.6	51.1
Sodium	mg/L	146	93.6	78.9
Sulfate	mg/L	304	124	124
Zinc	µg/L	< 4.0	5.93	< 5.0

Source: USGS, 2022e
Abbreviations: mg/L = milligrams per liter | µS/cm = microsiemens per centimeter | °C = degrees Celsius | pCi/l = picocuries per liter | µg/L = micrograms per liter

19.3.5 ECOLOGICAL RESOURCES

This section provides a description and characterization of the terrestrial and aquatic ecosystems potentially affected by the construction and operation of the EIPC. Consultations with the USFWS, New Mexico Department of Game and Fish (NMDGF), and Texas Parks & Wildlife Department (TPWD) were initiated to acquire information regarding ecological resources within and near the project site. Correspondence from USFWS, NMDGF, and TPWD was received and is incorporated into the below discussion. Documentation of agency consultation is provided in Appendix 19A. Consultation is used to obtain agency input regarding threatened and endangered species, sensitive habitats, commercial and recreational species, and other ecological characteristics for the project site and near-site areas.

19.3.5.1 Off-site Areas

Ecoregions are geographic areas that are generally similar in terms of biotic, abiotic, terrestrial, and aquatic ecosystem components. Ecoregions serve as a spatial framework for the monitoring, research, and assessment of ecosystems and their components. Ecoregions are defined in hierarchical levels from Level I through Level IV, increasing with detail as the level increases. The mapping of ecoregions is maintained by the USEPA (USEPA, 2022e).

New Mexico is divided into 55 Level IV ecoregions nested under eight Level III ecoregions, which may continue into ecologically similar parts of Colorado, Arizona, Oklahoma, and Texas. The project site and surrounding area within a 5-mi. (8-km) radius of the project site center point are located within the larger High Plains Level III ecoregion, as depicted in Figure 19.3.5-1. This ecoregion spans the eastern border of New Mexico and most of the Texas panhandle and is characterized by smooth to slightly irregular plains with a large amount of cropland. Grama-buffalo grass is typically abundant in this region (Griffith et al., 2006).

More specifically, the project site and off-site utility corridor are located within the Shinnery Sands Level IV ecoregion of Texas and New Mexico (Figure 19.3.5-1). The ecoregion contains flat sandy recharge areas, sand hills, and dunes. It is named after the Havard (shin) oak brush (*Quercus havardii*), which stabilizes sandy areas. Despite a potential vegetative cover of sandsage and prairie grasses, this vegetation is vulnerable to wind erosion and overgrazing. Portions of the ecoregion contain dense arrays of oil fields (Griffith et al., 2006). Characteristic animal species in the region are discussed below in Subsection 19.3.5.7.2, and potential animals on the project site can be found in Tables 19.3.5-1, 19.3.5-2, 19.3.5-3, and 19.3.5-4.

Common wildlife species that typically utilize these habitats for foraging, nesting, and protection include the southern plains woodrat (*Notoma micropus*), black-tailed prairie dog (*Cynomys ludovicianus)*, desert cottontail (*Sylvilagus audubonii*), spotted ground squirrel (*Spermophilus spilosoma*), swift fox (*Vulpes velox*), coyote (*Canis latrans*), and various hawks (NUREG-2239). Sensitive species that may occur within these habitats include the black-tailed prairie dog (*Cynomys ludovicianus*), burrowing owls (*Athene cunicularia*), Northern aplomado falcon (*Falco femoralis septentrionalis*), dunes sagebrush lizard (*Sceloporus arenicolus*), Texas horned lizard *(Phrynosoma cornutum*), and lesser prairie-chicken (*Tympanuchus pallidicinctus*) (NUREG-2239).

19.3.5.2 Site and Near-Site Areas

The project area consists of 245.6 ac. (99.4 ha) (Eden property and easement) located south of Hobbs and east of Eunice in Lea County, NM. Based on mapping available from the USGS

NLCD, more than 99 percent (245.6 ac. [99.4 ha]) of the project area is scrub/shrub habitat, with 0.01 percent developed, low intensity (see Subsection 19.3.1.1 and Table 19.3.1-1). The off-site utility corridor which extends along the north and south side of NM-176, west towards NM-18, consists of scrub/shrub habitat and some developed land use (see Subsection 19.3.1.1).

The Southwest Regional Gap Analysis Project (SWReGAP) began in 1999 to map and assess biodiversity for five western states (Arizona, Colorado, Nevada, New Mexico, and Utah). A land-cover product was completed in 2004 with the work of the USGS's Gap Analysis Project (GAP) and state institutions, including the Remote Sensing/Geographic Information Systems Laboratory at Utah State University (RS/GIS Laboratory, 2016). Seven different land cover classes are present within the project site boundary, as designated by the SWReGAP (Lowry et al., 2005; Table 19.3.5-5). SWReGAP mapping is similar to NLCD mapping in that more than 98 percent of the project site is mapped as scrub/shrub habitat (see Table 19.3.5-5).

The Apacherian-Chihuahuan Mesquite Upland Scrub land-cover class encompasses the majority of the project area (182.2 ac. [73.7 ha]; 74.2 percent). This ecological system consists of upland shrublands existing in the grassland–shrubland transition of the piedmont and foothills of the Chihuahuan Desert. Substrates are generally derived from alluvium, and winter precipitation is stored in deep soil layers. Grass cover is low. This system has increased as desert grasslands have been converted through drought, livestock overgrazing, or decreases in fire frequency (USGS GAP, 2005).

The second most prevalent land cover class on the project area is the Chihuahuan Creosotebush, Mixed Desert, and Thorn Scrub (30.3 ac. [12.3 ha]; 12.3 percent). This ecological system includes xeric creosotebush basins and plains and the mixed desert scrub in the foothill transition zone. Vegetation consists of creosotebush (*Larrea tridentata*) alone or in combination with thornscrub and other desert scrub. Grasses may be common but generally exhibit lower cover percentages than shrubs (USGS GAP, 2005).

The Western Great Plains Sandhill Shrubland encompasses 20.3 ac. (8.2 ha; 8.3 percent) of the project area. This ecological system ranges from the Nebraska Sandhills south to central Texas. Soils are well drained, sandy, and deep, often associated with old floodplains and dune systems. Vegetation is dominated by sand sagebrush (*Artemisia filifolia*) in a woody layer that ranges from sparse to moderately dense. Important dynamic processes for this system include fire, grazing, and drought. Overgrazing may lead to a decrease in dominance of some grass species (USGS GAP, 2005). The four remaining SWReGAP land cover types are minor, accounting for approximately five percent of the project site combined, and are listed in Table 19.3.5-5.

Land cover in the surrounding area (within a 5-mi. [8-km] radius around the project site center point) is summarized in Table 19.3.1-1. The SWReGAP does not cover Texas, so land cover within 5 mi. (8 km) of the project site was derived from the NLCD (Dewitz, 2021). Land cover is dominated by shrub and scrublands (46,225.6 ac. [18,706.9 ha]; 92.0 percent), similar in composition to the project site. Developed areas account for 3299.2 ac. (1335.1 ha), or just 6.5 percent, of the surrounding area. Cultivated crops consist of only 22.5 ac. (9.1 ha). Water resources are scarce within 5 mi. (8 km) of the project site: open water and woody wetlands occupy only 91.2 ac. (36.9 ha), which is less than one percent of the land cover (Dewitz, 2021). While no wildlife surveys have been conducted on the project site, a discussion of potential animal species is found below in Subsection 19.3.5.7.2.

As stated in Subsection 19.3.5.1, common wildlife species that may utilize habitat within and near the project site for foraging, nesting, and protection include the southern plains woodrat (*Notoma micropus*), black-tailed prairie dog (*Cynomys ludovicianus)*, desert cottontail (*Sylvilagus audubonii*), spotted ground squirrel (*Spermophilus spilosoma*), swift fox (*Vulpes velox*), coyote (*Canis latrans*), and various hawks (NUREG-2239).

19.3.5.3 History

Vegetative cover within the project site and surrounding area has been impacted by the grazing of domestic livestock and construction and operation of railroads and highways. At the proposed CISF for spent nuclear fuel in Andrews County, TX (approximately 3.0 mi. [4.8 km] northeast of the project site), domestic livestock have been grazing for over 100 years. Grazing and construction and operation of transportation infrastructure have caused a decrease in habitat quality, with little cover and water for larger animals and an impact to ground-nesting bird species. In addition, grazing can cause a vegetative shift from mature, climax communities to mid-successional communities with an invasion of woody species. Additionally, disturbed areas near the road have been invaded by weeds (ISP, 2020).

This vegetative shift due to heavy grazing has impacted the wildlife and has caused the faunal community to change from species associated with mature desert grassland to those associated with a grassland–shrub community. Mammalian and bird species depending on open or mature grasslands, such as the black-tailed prairie dog (*Cynomys ludovicianus*) and the lesser prairie chicken (*Tympanuchus pallidicinctus*), may have decreased in the area. Species thriving in a mid-successional plant community, such as the desert cottontail (*Sylvilagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), and mule deer (*Odocoileus hemionus*) have likely increased (ISP, 2020).

Other ecological stressors within the area surrounding the project site include oil and gas development and operations, which are prevalent in this part of the state (NUREG-1790).

19.3.5.4 Places and Entities of Special Interest

Few places and entities of special interest occur within the area surrounding the project site. New Mexico State Forestry Priority Landscapes, NMDGF Fish Management Plan Waters, NMDGF Riparian Corridors, New Mexico State Wildlife Action Plan (SWAP) Conservation Opportunity Areas, New Mexico Audubon Important Bird Areas, New Mexico Important Plant Areas, USFWS critical habitat, and USFWS refuges are absent (NMDGF, 2022a). No wetlands exist on the project site, as discussed in Section 19.3.4.

Approximately 360.2 ac. (145.8 ha) of public land administered by the BLM is mapped within a 5-mi. (8-km) radius of the project site (Figure 19.3.5-2). These lands are designated as “National Public Lands” and are within the jurisdiction of the BLM Carlsbad Field Office. They are open for public access and are managed for multiple uses, such as extractive mining or logging and off-highway vehicle use. A significant amount of New Mexico State Trust Land, 2889.7 ac. (1169.4 ha), is also mapped within 5 mi. (8 km) of the project site (Figure 19.3.5-2). This land is designated as a state resource management area, is open to the public, and has no known mandate for biodiversity protection (USGS GAP, 2022).

The Western Association of Fish and Wildlife Agencies manages a crucial habitat assessment tool (CHAT) to identify key wildlife corridors and crucial wildlife habitats in the western United States. The area surrounding the project site (a 5-mi. [8-km] radius around the project site

center point) has two areas labeled with CHAT rankings of "1," meaning that they have the most crucial habitat. A variety of considerations go into this overall crucial habitat ranking, and these areas generally have particularly important riparian and wetland habitat distribution, large natural areas, and terrestrial crucial habitat; however, because this tool is at a coarse scale, it does not delve into habitat considerations unique to each identified area (State Wildlife Agencies of the Western United States, 2022).

No known special interest areas occur within the project site boundary. However, New Mexico State Trust Land does occur within portions of the off-site utility corridor, as depicted in Figure 19.3.1-1. New Mexico state trust land has no known mandate for biodiversity protection.

19.3.5.5 Aquatic Communities and Potentially Affected Waterbodies

No permanent surface water features exist within the project site (see Subsection 19.3.4.1). As depicted on Figure 19.3.4-1, surface water features in the area surrounding the project site include an intermittent stream (Monument Draw) and several impoundments or manmade ponds. Baker Spring is another surface water feature near the project site (NUREG-1790). As both Monument Draw and Baker Spring hold water only intermittently, there are no associated aquatic communities. The manmade ponds and shallow depression areas to the north of the project site hold water perennially; however, these features primarily function as stormwater retention and industrial holding ponds (NUREG-1790); as such, they are not associated with any aquatic biota. No recreational or commercial fisheries exist near the project site, as no fishable surface water resources are present. Finally, no estuaries or oceans are near the project site.

19.3.5.6 Wetlands

The NHD and NWI were reviewed for potential wetland resources. Results of this review indicated that no wetlands occur within the project site. Within a 5-mi. (8-km) radius of the project site, NWI has mapped approximately 31.2 ac. (12.6 ha) of emergent wetlands and 95.7 ac. (38.7 ha) of scrub/shrub wetlands (Figure 19.3.4-2)(USFWS, 2022a).

19.3.5.7 Terrestrial Communities

This subsection provides a description and characterization of terrestrial communities within and near the project site (i.e., within a 5-mi. [8-km] radius of the site center point). While no surveys have been completed on the project site, the following descriptions are taken from surveys completed for the licensing of other facilities in the surrounding area. Species lists are limited only to species directly observed during field surveys for licensing at these other facilities (for further information, see Subsection 19.3.5.10).

19.3.5.7.1 Plant Communities

General vegetation in the Shinnery Sands Level IV ecoregion consists of dune-stabilizing shrubs, such as Havard shin oak, fourwing saltbush (*Atriplex canescens*), and yucca (*Yucca* sp.). Grasses and forbs present include sand verbena (*Abronia* sp.), bush sunflower (*Encelia* sp.), hoary rosemary-mint (*Poliomintha incana*), and fringed sagewort (*Artemisia frigida*) (Griffith et al., 2006).

Vegetation types within the area surrounding the project site include sandy shinnery shrubland, mesquite shrubland, sand prairie, mixed grass prairie, and shortgrass prairie vegetation types, as defined by the TPWD (NUREG-2239).

Mesquite shrubland provides habitat for reptiles, invertebrates, many bird species, and small mammals such as mice and squirrels. At areas around the project site, mesquite shrubland is dominated by the honey mesquite (*Prosopis glandulosa*), a native invasive shrub (ISP, 2020; Elliott, 2014). The sandy shinnery vegetation type is co-dominated by grasses and shinnery oak, which spreads by underground stems. Shinnery oak communities can be very old (hundreds to thousands of years) with oaks reaching heights of only 1 ft. to 4 ft. (0.3 to 1.2 m) (Peterson and Boyd, 1998).

A summary of plant species that have the potential to occur within the project site (taken from vegetation observed at a facility in the surrounding area) is found in Table 19.3.5-6. This table is composed of plants with preferred habitat matching habitat descriptions at the project site and those species which have been directly observed during field surveys at a facility in the surrounding area.

The New Mexico Rare Plant Technical Council identified two rare plants within Lea County. Greene milkweed (*Asclepias uncialis*) is a U.S. Forest Service sensitive species and a State of New Mexico strategy species, indicating that it should be protected from land use impacts when possible (NMRPTC, 1999). Greene milkweed is often associated with prairie or the grassland components within juniper woodlands, but the species has declined as a result of habitat modification for agriculture and livestock operations (NatureServe, 2022). While shortgrass prairie habitat occurs on the project site, historical grazing, as discussed in Subsection 19.3.5.3, makes it unlikely that Greene milkweed is present on the project site. Sticky tansy-aster (*Xanthisma viscidum*) has an “S2” state rank, meaning that it is imperiled in New Mexico, usually with only 6 – 20 occurrences or few remaining individuals (1000 – 3000) (NMRPTC, 1999). Sticky tansy-aster is found in sandy plains of deserts and is fairly common in oil and gas country (NatureServe, 2022). There is potential habitat for this species within the project site, but surveys at a facility in the surrounding area have not detected it, so it is excluded from Table 19.3.5-6.

The Texas Conservation Plan contains lists of species of greatest conservation need (SGCN) which are those species that are declining or rare and in need of attention to recover or prevent the need for state or federal listing (TPWD, 2023a). SGCN in Texas include plants, and there have been several SGCN plants identified within Andrews County, TX (TPWD, 2023b). A listing of all the SGCN for New Mexico and Texas is included in Table 19.3.5-7.

19.3.5.7.2 Wildlife

While no wildlife surveys have been conducted at the project site, this subsection describes the wildlife likely to be present near the project site and provides information on sensitive species that could occur at the project site. Facilities in the area surrounding the site have conducted surveys that included investigations for mammals, insects, reptiles, amphibians, and birds (see Subsection 19.3.5.10). This subsection discusses the species documented to occur at these nearby facilities based on the results of those surveys.

The New Mexico SWAP identified SGCN, which are species that have occurred within the state and were declining, vulnerable, endemic, disjunct, or a keystone species (NMDGF, 2022b). A variety of SGCN are present in Lea County as well as in Andrews County, TX. All the SGCN for

these two counties can be found in Table 19.3.5-7. The New Mexico SGCN are discussed in the following subsections for the respective taxonomic groups.

19.3.5.7.2.1 Mammals

Mammals with the potential to occur on the project site include mule deer and white-tailed deer (*Odocoileus virginianus*). Mule deer and white-tailed deer are economically important large mammals in New Mexico and Texas. NMDGF categorizes deer herds by game management units (GMUs). During the 2020 - 2021 hunting season, NMDGF estimated that 927 deer were harvested in GMU 31 (where the project site is located) (NMDGF, 2021a).

Pronghorn antelope (*Antilocapra americana*) may be found near the project site and are much less prevalent than deer in southeast New Mexico and the southern part of the Texas panhandle; however, they are still hunted and managed by each state. NMDGF estimated that 350 pronghorn were harvested in GMU 31 during the 2020 – 2021 hunting season (NMDGF, 2021b).

The only SGCN mammal within Lea County is the black-tailed prairie dog (*Cynomys ludovicianus*) (NMDGF, 2022c). Black-tailed prairie dogs are large rodents that live in open grasslands, eat grasses, and have been locally extirpated from parts of their range due to eradication efforts and plague (NMDGF, 2022d). As discussed in Subsection 19.3.5.3, the site and surrounding area have a long history of disturbance from grazing and transportation infrastructure; as such, the black-tailed prairie dog is unlikely to be present on the project site.

Based on input from NMDGF (Appendix 19A), Gunnison's prairie dog, another SGCN mammal in New Mexico, was evaluated for potential presence on or near the project site. However, based on information found in New Mexico's Biota Information System, the range of Gunnison's prairie dog does not extend into southeastern New Mexico (NMDGF, 2022e). Thus, this species is not expected to be present on or near the project site.

Mammals with the potential to occur within or near the project site are summarized in Table 19.3.5-1. The table is composed of mammals with a preferred habitat matching habitat descriptions at the project site and those species which have been directly observed during field surveys at facilities surrounding the project site.

19.3.5.7.2.2 Birds

Migratory birds fly between southern wintering grounds (Texas or Mexico) and northern nesting grounds (Canada) through the Central Flyway corridor that is centered approximately 300 mi. (483 km) east of the project site. These birds may use playa lakes in the area for food and water, if available (USFWS, 2022b; ISP, 2020). Waterfowl and shorebirds using the Central Flyway may include the mallard (*Anas platrhynchos*), great blue heron (*Ardea herodias*), gadwall (*Anas strepera*), and killdeer (*Charadrius vociferous*). Songbirds using the Central Flyway include the red-winged blackbird (*Agelaius phoeniceus),* vesper sparrow (*Pooecetes gramineus*), brown-headed cowbird (*Molothrus ater*), and dark-eyed junco (*Junco hyemalis*) (Johnsgard, 2012). Although the project site is located approximately 300 mi. (483 km) from the Central Flyway, the limited number of seasonal surface water features within the area surrounding the project site may provide potential resting or stopover habitat for migratory birds. Waterfowl and shorebirds may utilize playa lakes and manmade ponds near the project site but, due to a lack of surface water features, are not expected to occur within the project site.

The following 28 bird species identified as SGCN have been documented within Lea County (NMDGF, 2022c):

- Sprague's pipit (*Anthus spragueii*).
- Sagebrush sparrow (*Artemisiospiza nevadensis*).
- Burrowing owl (*Athene cunicularia*).
- American bittern (*Botaurus lentiginosus*).
- Baird's sparrow (*Centronyx bairdii*).
- Mountain plover (*Charadrius montanus*).
- Snowy plover (*Charadrius nivosus*).
- Common nighthawk (*Chordeiles minor*).
- Evening grosbeak (*Coccothraustes vespertinus*).
- Olive-sided flycatcher (*Contopus cooperi*).
- Broad-billed hummingbird (*Cynanthus latirostris*).
- Aplomado falcon (*Falco femoralis*).
- Peregrine falcon (*Falco peregrinus*).
- Bald eagle (*Haliaeetus leucocephalus*).
- Loggerhead shrike (*Lanius ludovicianus*).
- Virginia's warbler (*Leiothlypis virginiae*).
- Red-headed woodpecker (*Melanerpes erythrocephalus*).
- Long-billed curlew (*Numenius americanus*).
- Cassin's sparrow (*Peucaea cassinii*).
- Eared grebe (*Podiceps nigricollis*).
- Vesper sparrow (*Pooecetes gramineus*).
- Flammulated owl (*Psiloscops flammeolus*).
- Thick-billed longspur (*Rhynchophanes mccownii*).
- Black-throated gray warbler (*Setophaga nigrescens*).
- Williamson's sapsucker (*Sphyrapicus thyroideus*).
- Least tern (Sternula antillarum).
- Lesser prairie-chicken (*Tympanuchus pallidicinctus*).
- Bell's vireo (*Vireo bellii*).

The broad-billed hummingbird, least tern, bald eagle, aplomado falcon, peregrine falcon, Bell's vireo, and Baird's sparrow are state or federally protected species and are discussed further in Subsection 19.3.5.11. The lesser prairie-chicken is proposed for federal listing; it is a medium-sized grouse-like gamebird that prefers grasslands with shinnery oak or sand sagebrush.

Conversion or degradation of native grasslands, development, and shrub encroachment have the potential to affect this species; however, lesser prairie-chickens generally avoid vertical structures such as transmission lines and turbine towers (NMDGF, 2022f). As discussed in Subsection 19.3.5.3, the site and surrounding area have a long history of disturbance from grazing and transportation infrastructure. As such, the lesser prairie-chicken is unlikely to occupy the project site.

Burrowing owls are medium-sized owls that live in abandoned mammal burrows. These burrows may be dug by prairie dogs, ground squirrels, or other species. Burrowing owl populations have declined as prairie dog populations have declined (NMDGF 2023). As discussed in Subsection 19.3.5.7.2.1, black-tailed prairie dogs are unlikely to be present on the project site due to the long history of disturbance. This disturbance from grazing and transportation infrastructure, and the lack of burrows from prairie dogs, makes it similarly unlikely that burrowing owls are present on the project site.

The chestnut-collared longspur (*Calcarius ornatus*) is a USFWS bird of conservation concern throughout its range, which may include the project site and surrounding area, where it could potentially breed between May 1 and August 10 (USFWS, 2022c).

Other birds identified as SGCN have the potential to occur within or near the project site based on habitat requirements. Bird species with the potential to occur within or near the project site are listed in Table 19.3.5-2. This list is composed of birds with preferred habitat matching habitat descriptions at the project site and those species that have been directly observed during field surveys at facilities surrounding the project site.

19.3.5.7.2.3 Herpetofauna

Due to a lack of water features, amphibian species are not expected to occur within the project site. A variety of reptilian species may occur on the project site, including the western whiptail lizard (*Cnemidophorus tigris*), coachwhip (*Masticophis flagellum*), ornate box turtle (*Terrapene ornata*), and eastern fence lizard (*Sceloporus undulatus*) (Table 19.3.5-3).

Three reptile species identified as SCGN occur within Lea County: Sonoran mud turtle (*Kinosternon sonoriense sonoriense*), dunes sagebrush lizard (*Sceloporus arenicolus*), and western massasauga (*Sistrurus tergeminus*) (NMDGF, 2022c). The dunes sagebrush lizard is state endangered and discussed further in Subsection 19.3.5.11. Because the Sonoran mud turtle lives in freshwater habitats such as streams or ponds (NMDGF, 2022g), it is not expected to occur on the project site due the lack of surface water features. Finally, the western massasauga is a small rattlesnake typically found in desert grassland habitat and is usually nocturnal (NMDGF, 2022h). There is potential habitat for this species within the project site, but surveys at facilities in the surrounding area have not detected it, so it is not included in Table 19.3.5-3.

Herpetofauna with the potential to occur within or near the project site are summarized in Table 19.3.5-3. This table is composed of herpetofauna with preferred habitat matching habitat descriptions at the project site and those species which have been directly observed during field surveys at facilities surrounding the project site.

19.3.5.7.2.4 Insects

Insects and arachnids with the potential to occur on the project site are listed in Table 19.3.5-4. This table is composed of insects and arachnids directly observed during field surveys for licensing at facilities in the surrounding area of the project site. These species include, among others, robber flies (Asilidae), long-horned beetles (Cerambycidae), ants (Formicidae), katydids (Tettigoniidae), and widow spiders (Theridiidae) (Table 19.3.5-4). The monarch butterfly (*Danaus plexippus*) is a candidate for federal listing and has been documented in Lea County (NMDGF, 2022i). Monarch butterflies are found across the United States, using milkweed as their host plant. They migrate long distances (over 1860 mi. [3000 km]) to their overwintering sites in the fall (USFWS, 2022d).

19.3.5.8 Invasive Species

According to the New Mexico Department of Agriculture, the state maintains a list of noxious weeds and encourages landowners and land managers to target those species for control and/or eradication pursuant to the Noxious Weed Management Act of 1998 (NMDA, 2016). Within the area surrounding the project site (i.e., within a 5-mi. [8-km] radius around the project site center point), honey mesquite and prickly pear cacti (*Opuntia* sp.*)* are native but considered invasive. Honey mesquite is problematic on rangeland sites because it competes with other natives for soil moisture and because of its high reproductive ability. Other weedy native plant species, such as snakeweed (*Gutierrezia sarothrae)* and soapweed (*Yucca elata)*, are also present. Exotic forb species, such as Russian thistle (*Salsola iberica*), were also documented (ISP, 2020). Neither noxious nor invasive species were observed in prior surveys at the nearby CISF site (3.0 mi. [4.8 km] northeast of the project site), where surveys were performed in similar habitat (NUREG-2239).

Although surveys at the nearby CISF site in similar habitat indicate a low risk, Eden will conduct a preconstruction survey for invasive species.

Because no ponds, streams, or other water bodies occur on the project site, aquatic invasive species are not present.

19.3.5.9 Procedures and Protocols

No ecological procedures or management plans are in place for the project site, and no management has been conducted in the past. During construction, best management practices are used to minimize impacts on ecological resources.

19.3.5.10 Studies and Monitoring

No on-site ecological studies or monitoring programs have been implemented at the project site. In 2020, NV5 prepared a biological desktop review for the project site, which characterized soils, geology, water resources, plants, and wildlife; however, this review was desktop-based and not verified in the field.

Ecological field surveys at the neighboring URENCO site (1.3 mi. [2.1 km] northeast of the project site) were conducted in September 2003, October 2003, April 2004, May 2004, and June 2004. These surveys focused on mammals, birds, reptiles, amphibians, and vegetative cover (NUREG-1790). Ecological assessments focused on licensing at the proposed CISF site (3.0 mi. [4.8 km] northeast of the project site) began in 1997, with the most recent occurring in 2018

– 2019 (Cox McLain Environmental Consulting, 2019). Because of their proximity, these studies have been used to inform the preparation of this Environmental Report.

19.3.5.11 Protected Species and Habitats

The USFWS Environmental Conservation Online System Information for Planning and Consultation (USFWS, 2022c), New Mexico's Biota Information System (NMDGF, 2022i), and the TPWD Rare, Threatened, and Endangered Species of Texas by County search tool (TPWD, 2023b) generated reports of the animal species considered by the states or federal government to be endangered or threatened and whose known or suspected ranges are within 5 mi. (8 km) of the project site. The reports returned eleven species that are endangered or threatened; results of the reports are summarized in Table 19.3.5-8. Based on descriptions of these species' preferred habitat in Table 19.3.5-8, only the Texas horned lizard, northern aplomado falcon, and Baird's sparrow have potential to occur within the project site.

The State of New Mexico identifies the least tern, northern aplomado falcon, and dunes sagebrush lizard as endangered. The USFWS also identifies the northern aplomado falcon as endangered, and aerial photographs show potential for the falcon's habitat within the project site, as documented in the biological desktop study; however, within Arizona and New Mexico, the northern aplomado falcon is classified as a non-essential, experimental population. This means that these falcons are being reintroduced into historical habitat in southern New Mexico to establish a resident population in Arizona and New Mexico. This designation means that fewer land-use restrictions are associated with the treatment of this species (USFWS, 2006). No suitable habitat for either the least tern or the dunes sagebrush lizard is present within the project site (Table 19.3.5-8).

The broad-billed Hummingbird, bald eagle, peregrine falcon, Bell's vireo, and Baird's sparrow are all state-threatened species that have the potential to occur near the project site (NMDGF, 2022i). No suitable habitat exists on the project site for any these species except the Baird's sparrow. Aerial photographs have shown that grassland habitat is present at the project site (Table 19.3.5-8). The Baird's sparrow winters in dry grasslands in the western United States and is only present in New Mexico for wintering. Because it typically stays low in the grass habitat, it is primarily identified by song (NMDGF, 2022j).

The State of Texas identifies the Texas horned lizard and white-faced ibis (*Plegadis chihi*) as threatened (TPWD, 2023b). No suitable habitat exists for the white-faced ibis on the project site as there are no water resources (see Subsection 19.3.5.5; Table 19.3.5-8). Because Texas horned lizards use open habitats with sparse vegetation including scattered brush or scrubby trees (TPWD, 2023b), scrub/shrub habitat on-site (see Subsection 19.3.5.2) may provide suitable habitat for this species (Table 19.3.5-8). Although suitable habitat for the Texas horned lizard may occur on-site, the site is wholly located within the State of New Mexico; not the State of Texas where it is listed.

No critical habitat for any endangered species is present within or near the project site (USFWS, 2022c).

Finally, no federal- or state-listed plants are found within Lea County (NMRPTC, 1999). Within Andrews County, the dune umbrella-sedge (*Cyperus onerosus*) is listed as state threatened (TPWD, 2023b). Because the dune umbrella-sedge inhabits moist to wet sand in depressions among active or partially stabilized sand dunes, there is no suitable habitat for this species on the project site because there are no active sand dunes (TPWD, 2023b; Table 19.3.5-8).

Table 19.3.5-1
Mammals with Potential to Occur on the Project Site[a]

Scientific Name	Common Name	Preferred Habitat
Antilocapra americana	Pronghorn antelope	Sagebrush flats, plains, and deserts
Canis latrans	Coyote	Open space, grasslands, and brush country
Chaetodipus hispidus	Hispid pocket mouse	Scattered weeds and shrubs
Dicotyles tajacu	Collared peccary	Brushy, semi-desert, chaparral, mesquite, and oaks
Dipodomys ordii	Ord's kangaroo rat	Hard desert soils
Geomys bursarius	Plains pocket gopher	Deep soils of the plains
Lepus californicus	Black-tailed jackrabbit	Grasslands and open areas
Mephitis mephitis	Striped skunk	All land habitats
Neotoma albigula	White-throated woodrat	Grasslands, prairies, and mixed vegetation
Neotoma micropus	Southern Plains woodrat	Grasslands, prairies, and mixed vegetation
Odocoileus hemionus	Mule deer	Desert shrubs, chaparral, and rocky uplands
Odocoileus virginianus	White-tailed deer	Riparian drainages, grasslands, and brush country
Pappogeomys castanops	Yellow-faced pocket gopher	Deep soils of the plains
Peromyscus eremicus	Cactus mouse	Grasslands, prairies, and mixed vegetation
Peromyscus maniculatus	Deer mouse	Grasslands, prairies, and mixed vegetation
Procyon lotor	Raccoon	Brushy, semi-desert, chaparral, and mesquite
Spermophilus spilosoma	Spotted ground squirrel	Brushy, semi-desert, chaparral, mesquite, and oaks
Sylvilagus audubonii	Desert cottontail	Arid lowlands, brushy cover, and valleys
Vulpes velox	Swift fox	Rangeland short grasses and low shrub density

Source: NUREG-1790, NUREG-2239
a) Species list is compiled from those species listed as potentially occurring at the CISF and URENCO sites and based on habitat available at the proposed EIPC site.
Abbreviations: CISF = Consolidated Interim Storage Facility | URENCO = Uranium Enrichment Corporation | EIPC = Eden Isotope Production Complex

Table 19.3.5-2
(Sheet 1 of 2)
Birds with Potential to Occur on the Project Site[(a)]

Scientific Name	Common Name	Preferred Habitat
Amphispiza bilineata	Black-throated sparrow	Canyons, desert washes, and desert scrub
Buteo jamaicensis	Red-tailed hawk	Multiple open habitats: deserts, scrublands, grasslands, roadsides
Buteo swainsoni	Swainson's hawk	Prairie and grassland; favor open habitats for foraging
Calamospiza melanocorys	Lark bunting	Grassland and shrub steppe
Callipepla squamata	Scaled quail	Desert grasslands and shrublands
Campylorhynchus brunneicapillus	Cactus wren	Scrubby areas in the Chihuahuan, Sonoran, and Mojave deserts
Cardinalis sinuatus	Pyrrhuloxia	Upland desert, mesquite savanna, desert scrublands, riparian (streamside) woodlands
Cathartes aura	Turkey vulture	Open woodlands, including mixed farmland, forest, and rangeland
Charadrius vociferous	Killdeer	Open areas, such as sandbars, mudflats, and grazed fields; common in dry areas
Chondestes grammacus	Lark sparrow	Open grassy habitats with scattered trees and shrubs
Chordeiles minor	Common nighthawk	Nest in rural and urban habitats, including prairies, plains, sagebrush, and grasslands
Colinus virginianus	Northern bobwhite	Agricultural fields, grasslands, open pine or pine-hardwood forests, and grass-brush rangelands
Corvus corax	Common raven	Nearly any habitat, including chaparral, sagebrush, desert, grasslands
Corvus cryptoleucus	Chihuahuan raven	Grasslands and deserts with yucca and scattered small trees
Falco sparverius	American kestrel	Open areas with short ground vegetation and sparse trees
Geococcyx californianus	Greater roadrunner	Semi-open, scrubby habitat
Haemorhous mexicanus	House finch	Human-created habitats, dry desert, desert grassland, chaparral

Table 19.3.5-2
(Sheet 2 of 2)
Birds with Potential to Occur on the Project Site[a]

Scientific Name	Common Name	Preferred Habitat
Icterus parisorum	Scott's oriole	Arid foothills and mountains down to desert; nest in desert oases with taller trees
Lanius ludovicianus	Loggerhead shrike	Open country with short vegetation and well-spaced shrubs or low trees
Mimus polyglottos	Northern mockingbird	Open ground and with shrubby vegetation
Molothrus ater	Brown-headed cowbird	Grasslands with low and scattered trees, woodland edges, prairies, fields
Myiarchus cinerascens	Ash-throated flycatcher	Dry scrub, open woodlands, and deserts
Passerina caerulea	Blue grosbeak	Multiple habitats, including a small number of tree species, little canopy coverage, and low shrub density
Peucaea cassinii	Cassin's sparrow	Dry grasslands with scattered shrubs or small trees
Pooecetes gramineus	Vesper sparrow	Open areas with short, sparse grass and scattered shrubs
Quiscalus mexicanus	Great-tailed grackle	Chaparral, second-growth forest, agricultural and urban settings
Sturnella neglecta	Western meadowlark	Open grasslands, prairies, meadows, and some agricultural fields
Sturnus vulgaris	European starling	Human-created habitat such as mowed lawns, city streets, agricultural fields
Thyromanes bewickii	Bewick's wren	Brushy areas, scrub and thickets in open country, or open woodland
Toxostoma curvirostre	Curve-billed thrasher	Open country, including brushlands, thorn scrub with mesquite, or desert flats
Tyrannus forficatus	Scissor-tailed flycatcher	Savannas with scattered trees, shrubs, and patches of brush
Tyrannus verticalis	Western kingbird	Grasslands, desert shrub, savannah
Zenaida macroura	Mourning dove	Open country, scattered trees, and woodland edges
Zonotrichia leucophrys	White-crowned sparrow	Open or shrubby habitats

Source: NUREG-1790, NUREG-2239; Cornell Lab of Ornithology, 2019
a) Species list is compiled from those species listed as potentially occurring at the CISF and URENCO sites and based on habitat available at the proposed EIPC site.
Abbreviations: CISF = Consolidated Interim Storage Facility | URENCO = Uranium Enrichment Corporation | EIPC = Eden Isotope Production Complex

Table 19.3.5-3
Herpetofauna with Potential to Occur on the Project Site[a]

Scientific Name	Common Name	Preferred Habitat
Cnemidophorus sexlineatus	Six-lined racerunner	Mixed-grass prairie and desert grasslands
Cnemidophorus tigris	Western whiptail lizard	Mixed grass prairie and desert grasslands
Crotalus atrox	Western diamondback rattlesnake	Grasslands and rocky areas
Crotaphytus collaris	Collared lizard	Desert grasslands
Gambelia wislizenii	Longnose leopard lizard	Mixed-grass prairie and desert grasslands
Eumeces obsoletus	Great Plains skink	Grasslands with fine soils
Holbrookia maculata	Lesser earless lizard	Mixed-grass prairie and desert grasslands
Masticophis flagellum	Coachwhip	Mixed-grass prairie and desert grasslands
Phrynosoma cornutum	Texas horned lizard	Desert grasslands
Pituophis melanoleucus	Pine-gopher snake	Short-grass prairie and desert grasslands
Rhinocheilus lecontei	Long nosed snake	Desert grasslands
Sceloporus undulatus	Eastern fence lizard	Mixed-grass prairie and desert grasslands
Sonora semiannulata	Ground snake	Desert grasslands
Tantilla nigriceps	Plains blackhead snake	Short-grass prairie and desert grasslands
Terrapene ornata	Ornate box turtle	Desert grasslands and short-grass prairie
Thamnophis sp.	Garter snake	Desert grasslands
Uta stansburiana	Desert side-blotched lizard	Desert shrubs

Source: NUREG-1790, NUREG-2239
a) Species list is compiled from those species listed as potentially occurring at the CISF and URENCO sites and based on habitat available at the proposed EIPC site.
Abbreviations: CISF = Consolidated Interim Storage Facility | URENCO = Uranium Enrichment Corporation | EIPC = Eden Isotope Production Complex

Table 19.3.5-4
(Sheet 1 of 2)
Insects and Arachnids with Potential to Occur on the Project Site[a]

Family	Common Name	Preferred Habitat
	Insect Families	
Acridiae	Grasshoppers	No habitats specified for insects and arachnids
Anthicidae	Ant-like beetles	
Asilidae	Robber flies	
Blattidae	Roaches	
Braconidae	Parasitoid wasps	
Cantharidae	Soldier beetles	
Carabidae	Ground and tiger beetles	
Cerambycidae	Long-horned beetles	
Chalcididae	Wasps	
Chrysomelidae	Leaf beetles	
Cicadidae	Cicadas	
Coccinellidae	Lady bugs	
Coreidae	Squash bugs	
Curculionidae	Snout beetles	
Formicidae	Ants	
Geometridae	Larval moths	
Gryllidae	Crickets	
Ichneumonidae	Wasps	
Lepidoptera	Moths	
Lygaeidae	Milkweed bugs	
Mantidae	Mantids	
Meloidae	Blister beetles	
Melyridae	Soft winged flower beetles	
Membracidae	Treehoppers	
Monotomidae	Dark beetles	
Mutillidae	Velvet ants	
Nitidulidae	Sap beetles	
Pentatonidae	Stink bugs	
Phasmatidae	Walking sticks	
Proctotrupidae	Wasps	
Psyllidae	Plant louse	
Pyrrhocoridae	Red bugs	

Table 19.3.5-4
(Sheet 2 of 2)
Insects and Arachnids with Potential to Occur on the Project Site[a]

Family	Common Name	Preferred Habitat
	Insect Families (*continued*)	
Reduviidae	Assassin bugs	No habitats specified for insects and arachnids
Scarabaeidae	June bugs, dung beetle	
Sphecidae	Wasps	
Tenebrionidae	Darkling beetles	
Tettigoniidae	Katydids	
Vespidae	Paper wasps	
	Arachnid Families	
Salticidae	Crab spiders (jumping spiders)	No habitats specified for insects and arachnids
Theridiidae	Widow spiders	
Trombidiidae	Velvet mites	

Source: NUREG-2239
a) Species list is compiled from those species listed as potentially occurring at the CISF site and based on habitat available at the proposed EIPC site.
Abbreviations: CISF = Consolidated Interim Storage Facility | URENCO = Uranium Enrichment Corporation | EIPC = Eden Isotope Production Complex

Table 19.3.5-5
Summary of SWReGAP Land Cover within the Project Area

SWReGAP Land Cover Class	Acres	Percent
Apacherian-Chihuahuan Mesquite Upland Scrub	182.2	74.2%
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	0.9	0.4%
Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	30.3	12.3%
Chihuahuan Mixed Salt Desert Scrub	8.9	3.6%
Chihuahuan Sandy Plains Semi-Desert Grassland	1.2	0.5%
Western Great Plains Sandhill Shrubland	20.3	8.3%
Western Great Plains Shortgrass Prairie	1.8	0.7%
Total	**245.6**	**100%**

Source: Lowry et al., 2005
Abbreviations: SWReGAP = Southwest Regional Gap Analysis Project

Table 19.3.5-6
(Sheet 1 of 2)
Plant Species with Potential to Occur on the Project Site[a]

Scientific Name	Common Name
Trees and Woody Shrubs	
Atriplex canescens	Fourwing saltbush
Prosopis glandulosa	Honey mesquite
Quercus havardii	Shinnery oak/Havard oak
Schinus molle	Peruvian peppertree
Ulmus pumila	Siberian elm
Grasses, Subshrubs, and Herbs	
Amaranthus sp.	Pigweed
Ambrosia artemisiifolia	Annual ragweed
Artemisia filifolia	Sand sagebrush
Aristida purpurea	Purple threeawn
Brickellia eupatorioides	False boneset
Bouteloua gracilis	Blue grama
Bouteloua hirsuta	Hairy grama
Cenchrus spinifex	Coastal sandbur
Chamaesyce sp.	Sandmat
Chloris cucullata	Hooded windmill grass
Chrysopsis pilosa	Soft goldenaster
Croton monanthogynus	Prairie tea
Descurainia pinnata	Western tansymustard
Dimorphocarpa wislizeni	Touristplant
Echinocactus texensis	Horse crippler
Eragrostis lehmanniana	Lehmann lovegrass
Eragrostis secundiflora	Red lovegrass
Ephedra trifurca	Longleaf jointfir
Gutierrezia sarothrae	Broom snakeweed
Heterotheca subaxillaris	Camphorweed
Ipomopsis longiflora	Flaxflowered ipomopsis
Melampodium leucanthum	Plains blackfoot
Mirabilis linearis	Narrowleaf four o'clock
Nassella leucotricha	Texas wintergrass
Opuntia sp.	Prickly pear
Packera cana	Woolly groundsel
Paspalum dilatatum	Dallisgrass

Table 19.3.5-6
(Sheet 2 of 2)
Plant Species with Potential to Occur on the Project Site[a]

Scientific Name	Common Name
Grasses, Subshrubs, and Herbs (*continued*)	
Schizachyrium scoparium	Little bluestem
Senecio flaccidus	Threadleaf ragwort
Senna bauhinioides	Twinleaf senna
Setaria vulpiseta	Plains bristlegrass
Solanum elaeagnifolium	Silverleaf nightshade
Sorghastrum nutans	Indiangrass
Sphaeralcea coccinea	Scarlet globe mallow
Sporobolus indicus	Smut grass
Stillingia sylvatica	Queen's-delight
Yucca sp.	Yucca

Source: Cox McLain Environmental Consulting, 2019
a) Species list is compiled from those species listed as potentially occurring at the CISF site and based on habitat available at the proposed EIPC site.
Abbreviations: CISF = Consolidated Interim Storage Facility | URENCO = Uranium Enrichment Corporation | EIPC = Eden Isotope Production Complex

Table 19.3.5-7
(Sheet 1 of 3)
Species of Greatest Conservation Need in Andrews County, Texas, and Lea County, New Mexico

Scientific Name	Common Name	State Listed as SGCN
	Plants	
Cyperus onerosus	Dune umbrella-sedge[(a)]	TX
Ephedra coryi	Cory's ephedra	TX
Eurytaenia hinckleyi	Hinckley's spreadwing	TX
Proboscidea sabulosa	Dune unicorn-plant	TX
	Mammals	
Antilocapra americana	Pronghorn	TX
Conepatus leuconotus	Western hog-nosed skunk	TX
Cynomys ludovicianus	Black-tailed prairie dog	NM, TX
Lasiurus borealis	Eastern red bat	TX
Lasiurus cinereus	Hoary bat	TX
Mustela frenata	Long-tailed weasel	TX
Nyctinomops macrotis	Big free-tailed bat	TX
Puma concolor	Mountain lion	TX
Spilogale gracilis	Western spotted skunk	TX
	Birds	
Anthus spragueii	Sprague’s pipit	NM
Aquila chrysaetos	Golden eagle	TX
Artemisiospiza nevadensis	Sagebrush sparrow	NM
Athene cunicularia hypugaea	Western burrowing owl	NM, TX
Botaurus lentiginosus	American bittern	NM
Calamospiza melanocorys	Lark bunting	TX
Calcarius ornatus	Chestnut-collared longspur	TX
Centronyx bairdii	Baird’s sparrow[(a)]	NM

Table 19.3.5-7
(Sheet 2 of 3)
Species of Greatest Conservation Need in Andrews County, Texas, and Lea County, New Mexico

Scientific Name	Common Name	State Listed as SGCN
	Birds (*continued)*	
Charadrius montanus	Mountain plover	NM, TX
Charadrius nivosus	Snowy plover	NM
Chordeiles minor	Common nighthawk	NM
Coccothraustes vespertinus	Evening grosbeak	NM
Contopus cooperi	Olive-sided flycatcher	NM
Cynanthus latirostris	Broad-billed hummingbird[(a)]	NM
Falco femoralis	Northern Aplomado falcon[(a)]	NM
Falco peregrinus	Peregrine falcon[(a)]	NM
Haliaeetus leucocephalus	Bald eagle[(a)]	NM, TX
Lanius ludovicianus	Loggerhead shrike	NM
Leiothlypis virginiae	Virginia’s warbler	NM
Leucophaeus pipixcan	Franklin's gull	TX
Melanerpes erythrocephalus	Red-headed woodpecker	NM
Numenius americanus	Long-billed curlew	NM
Peucaea cassinii	Cassin’s sparrow	NM
Plegadis chihi	White-faced ibis[(a)]	TX
Podiceps nigricollis	Eared grebe	NM
Pooecetes gramineus	Vesper sparrow	NM
Psiloscops flammeolus	Flammulated owl	NM
Rhynchophanes mccownii	Thick-billed longspur	NM
Setophaga nigrescens	Black-throated gray warbler	NM
Sphyrapicus thyroideus	Williamson's Sapsucker	NM
Sternula antillarum	Least tern[(a)]	NM

Table 19.3.5-7
(Sheet 3 of 3)
Species of Greatest Conservation Need in Andrews County, Texas, and Lea County, New Mexico

Scientific Name	Common Name	State Listed as SGCN
	Birds (*continued)*	
Tympanuchus pallidicinctus	Lesser prairie-chicken	NM, TX
Vireo bellii	Bell's vireo[(a)]	NM
	Herpetofauna	
Anaxyrus woodhousii	Woodhouse's toad	TX
Crotalus viridis	Western rattlesnake	TX
Heterodon nasicus	Western hognose snake	TX
Kinosternon sonoriense sonoriense	Sonoran mud turtle	NM
Lithobates blairi	Plains leopard frog	NM
Phrynosoma cornutum	Texas horned lizard[(a)]	TX
Phrynosoma modestum	Roundtail horned lizard	TX
Sceloporus arenicolus	Dunes sagebrush lizard[(a)]	NM, TX
Sistrurus tergeminus	Western massasauga	NM, TX
Terrapene ornata	Western box turtle	TX
	Insects	
Polyphylla monahansensis	Monahans lined june beetle	TX
Polyphylla pottsorum	No accepted common name	TX
	Crustaceans	
Artemia franciscana	Brine shrimp	NM
Branchinecta lindahli	Versatile fairy shrimp	NM

Source: TPWD, 2023b; NMDGF, 2022c
a) State or federally protected species that are discussed in Subsection 19.3.5.11 and Table 19.3.5-8.
Abbreviations: TX = Texas | NM = New Mexico | SGCN = species of greatest conservation need

Table 19.3.5-8
(Sheet 1 of 2)
State and Federally Protected Species with Potential to Occur on the Project Site

Common Name ***Scientific Name***	**New Mexico Designation**	**Texas Designation**	**Federal Designation**	**Preferred Habitat**	**Potential to Occur on Project Site**
Least tern *Sternula antillarum*	Endangered	None	None	Nests on ground, generally on sites that are sandy and relatively free of vegetation (e.g., alkali flats).	None. This species is a colonial-nesting water bird and there are no water resources on the project site.
White-faced ibis *Plegadis chihi*	None	Threatened	None	Freshwater marshes, sloughs, and irrigated rice fields.	None. There are no water resources on the project site.
Northern aplomado falcon *Falco femoralis*	Endangered	None	Experimental	Yucca grasslands and adjacent shrubby habitats at lower elevations.	Yes. Aerial photographs show potential for this habitat on the project site.
Broad-billed hummingbird *Cynanthus latirostris*	Threatened	None	None	Riparian woodlands at low-to-moderate elevations.	None. The project site does not have any riparian woodlands.
Bell's vireo *Vireo bellii*	Threatened	None	None	Dense shrubland or woodland along lowland stream courses, with willows, mesquite, and seepwillows.	None. The project site does not contain shrubland or woodland habitats near streams.
Bald eagle *Haliaeetus leucocephalus*	Threatened	None	None[(a)]	Timbered areas along coasts, large lakes, and rivers.	None. There are no water resources on the project site.
Peregrine falcon *Falco peregrinus*	Threatened	None	None	Various forest types in New Mexico.	None. The project site does not contain forest habitat.
Dunes sagebrush Lizard *Sceloporus arenicolus*	Endangered	None	None	Most abundant in shinnery oak-sand dune habitats where uneven sandy terrain and wind-created blowouts are essential habitat requirements.	None. The project site is within the Shinnery Sands Level IV Ecoregion but does not contain any essential sand dunes.

Table 19.3.5-8
(Sheet 2 of 2)
State and Federally Protected Species with Potential to Occur on the Project Site

Common Name ***Scientific Name***	**New Mexico Designation**	**Texas Designation**	**Federal Designation**	**Preferred Habitat**	**Potential to Occur on Project Site**
Texas horned lizard *Phrynosoma cornutum*	None	Threatened	None	Open habitats with sparse vegetation, including grass, scattered brush, or scrubby trees.	Yes. There is scrub/shrub habitat on the project site.
Baird's sparrow *Centronyx bairdii*	Threatened	None	None	Variety of habitats, including desert grasslands and High Plains Ecoregion; breeds in shortgrass prairies.	Yes. Aerial photographs show grassland habitat is present at the project site.
Dune umbrella-sedge *Cyperus onerosus*	None	Threatened	None	Moist to wet sand in depressions among active or partially stabilized sand dunes.	None. The project site does not contain essential sand dunes.

Source: TPWD, 2023b
a) Not listed under Endangered Species Act but protected under the Bald and Golden Eagle Protection Act.

19.3.6 HISTORIC AND CULTURAL RESOURCES

Historic and cultural resources include but are not limited to: (i) prehistoric era and historic era archaeological sites, artifacts, and remains; (ii) historic sites, districts, and buildings; and (iii) traditional cultural properties that are important to a group, such as an Indian Tribe, for maintaining their culture. When cultural resources meet any one of the National Register Criteria for Evaluation (Title 36 of the Code of Federal Regulations [CFR] 60.4), they may be termed historic properties and be eligible for inclusion in the National Register of Historic Places (NRHP). *Historic property* is the legal term for a historic and/or cultural resource that is eligible for listing on the NRHP (36 CFR Part 60) (i.e., more than 50 years old). Traditional cultural properties can also meet NRHP criteria and be considered historic properties.

A 100-percent, intensive cultural resource survey was conducted to identify the potential occurrence of archaeological and historic resources potentially eligible for the NRHP on the project site and to determine whether any are located in the area of potential effect (APE). Identified resources were assessed against the criteria for the NRHP in order to determine their potential eligibility. The cultural resources survey is provided in Appendix 19B. In addition, the qualifications of the survey personnel are provided as an attachment to Appendix 19B.

19.3.6.1 Cultural Setting

The cultural background of New Mexico spans thousands of years. The earliest groups to leave a definitive material record of their presence were early Paleoindians, who entered the region approximately 13,500 years ago during the Late Pleistocene Epoch. Their descendants and the descendants of other Native American groups who migrated to the area later occupied the region for the next 11 millennia. This long prehistoric era lasted until the arrival of European explorers in the 15th century.

While cultural change is a slow and continual process, archaeologists and other researchers divide the human history of the region in which the project site is located into distinct cultural periods. Archaeologists and historians recognize five broadly defined periods for New Mexico:

- Paleoindian (approximately 11,500 – 5000 BC).
- Archaic (8800 BC – AD 400).
- Formative (AD 400 – AD 1200).
- Protohistoric (AD 1200 – AD 1500).
- Historic (AD 1500 – Present).

According to the New Mexico Historic Preservation Division, the distinction of these periods relies heavily on the different types of subsistence practices utilized and cultural traits present (NMHPD, 2001). The Paleoindian Period is characterized by nomadic hunting and gathering that focused on large megafauna game. Due to the extinction of the large megafauna, the Archaic time period saw a change to focus on smaller game and the initial exploitation of domesticated plants. During the Formative Period, sedentism flourished with the expanded utilization of domesticated plants. The Protohistoric Period accounts for the time when the Spanish initially explored the region, and the Historic Period represents the Spanish colonial occupation through present day (NMHPD, 2001).

19.3.6.2 Previous Investigations

The direct APE for this project consists of the project site, which includes all potential ground disturbance related to the construction, operation, and decommissioning of the EIPC. The indirect APE consists of that area potentially affected by visual effects and noise sources arising from the project. Because of the low profile of the proposed project and the existence of other buildings, roads, and nearby structures, the extent of the visual APE (i.e., the indirect APE) is limited to the areas within a 0.3-mi. (0.5-km) radius extending from the proposed project boundary.

Records on file at the Museum of New Mexico Archaeological Records Management System (ARMS) were examined (January 29, 2020) to determine whether any previously conducted cultural resource investigations were located within the project site or within a 0.3-mi. (0.5-km) buffer surrounding the project site (Appendix 19B).

According to the ARMS site file and database research, one previous cultural resource survey (Proper, 2007) is located wholly within the off-site utility corridor and one previous cultural resource survey (Graves, 2004) is located within 0.3 mi. (0.5 km) of the project site, neither of which identified cultural resources (Appendix 19B). No archaeological sites had been recorded within or immediately adjacent to the project site prior to the cultural resource survey. Additionally, the State Register of Cultural Properties and the NRHP were consulted; no listed properties are within the project site or near the project site.

The nearby URENCO facility performed a cultural resource survey on their site as part of their original licensing action for the present gas centrifuge U enrichment facility. The survey identified seven archaeological sites on the URENCO site, and the New Mexico State Historic Preservation Office (SHPO) determined that they were all eligible for listing on the NRHP and would be adversely affected by the URENCO project (NRC, 2015). As these adverse effects required mitigation, the NRC developed a memorandum of agreement among the NRC, the SHPO, the New Mexico State Land Office, Lea County, NM, and URENCO that stated that all seven of the sites would be excavated and that data recovery would be conducted before construction began to mitigate adverse effects (NRC, 2015).

In addition, outside the APE for the project, although nearby, cultural resource surveys were conducted at the International Isotopes Fluorine Products, Inc. (IIFP) facility and the CISF as part of initial licensing. At the IIFP facility, the cultural resource survey identified three isolated occurrences and no archaeological sites. All the isolated occurrences were ineligible for inclusion on the NRHP, and no further work was recommended (IIFP, 2009). At the CISF facility, no cultural resources were identified during the survey (NUREG-2239). The low frequency of cultural resources in the area may be attributed to the presence of shallow soils and lack of permanent available water.

An off-site utility corridor, centered on NM-176 is utilized to connect the project site to utilities. The northern portion of the utility corridor, north of NM-176, has been previously surveyed for cultural resources (Proper, 2007) and none were identified. Utilities for the project site are sited within the previously surveyed section of the off-site utility corridor. If utilities cannot be limited to the previously surveyed section of the off-site corridor, a cultural resource survey will be performed before any ground disturbances are conducted.

19.3.6.3 Current Investigations

After reviewing obtainable information about cultural resources within and surrounding the project site, a 100-percent, intensive cultural resource survey was conducted by qualified professionals in the state of New Mexico to determine whether unidentified cultural resources were present (Appendix 19B).

The field survey was conducted on February 4 – 7, 2020 and March 25 – 26, 2020 under New Mexico State Permit No. 20-160-S. In accordance with SHPO guidelines, a total of 319.56 ac. (129.32 ha) was surveyed, which included a 100-ft. (30-m) buffer added to the south, east, and west borders of the project site and a 50-ft. (15-m) buffer along the proposed access route. The report was amended in August 2022 to add the project Universal Transverse Mercator (UTM) location data. No archaeological sites were identified during the cultural resource survey; however, six isolated occurrences were identified that included one sardine can fragment, one quartzite hammerstone, five fragments of a Ball canning jar, two chalcedony flakes, one clear glass bottle, and metal can fragments. All the isolated occurrences identified were determined to be ineligible for inclusion on the NRHP, and no further work was recommended (Appendix 19B). A historic architecture survey was not completed as part of the current investigations.

19.3.6.4 Consultation

Consultation efforts with the SHPO, Tribal Historic Preservation Offices, American Indian Tribe(s), and/or members of the public was conducted to assess the presence of historic and cultural resources within the APE. A written consultation letter was submitted on September 30, 2022, that included the transmittal of the results of the cultural resource survey (see Appendix 19A, Regulatory Consultation Correspondence). The purpose of the letter is to support regulatory review pursuant to Section 106 of the National Historic Preservation Act. Full compliance with Section 106 consultation is conducted in conjunction with the NRC. A response from the SHPO was received in a letter dated October 14, 2022 (Appendix 19A). In this letter, New Mexico SHPO had no concerns regarding the findings of the archaeological investigation and have no other comments or information to provide for the proposed facility. Due to the facility being licensed by the NRC, the NRC must consult with the New Mexico SHPO and request concurrence with an effect determination based on the cultural resource survey and the results of their consultation with Native American Tribes.

19.3.7 SOCIOECONOMICS

This section characterizes the demographic, economic, and community characteristics of the region surrounding the project site. For the majority of this section, this region is defined as the three counties surrounding the project where the construction and operation workforce reside, as these counties likely incur the greatest potential impact to community services. This region is also referred to as the region of influence (ROI) and is defined by the three counties surrounding the center point of the project site:

- Lea County, NM
- Andrews County, TX
- Gaines County, TX

As the project site is located within Lea County, NM, the construction and operation workforces reside primarily in five population centers within the three-county ROI, consisting of the following municipalities (see Figure 19.3.7-1):

- Eunice, NM
- Hobbs, NM
- Jal, NM
- Andrews, TX
- Seminole, TX

The data used in this section are the most current and complete data identified to characterize the socioeconomic conditions within the ROI. In most cases, those data represent relatively current conditions in the region (e.g., 2016 – 2020 American Community Survey [ACS] five-year estimates provided by the U.S. Census Bureau [USCB] and USCB 2020 Decennial Census data) or projected conditions. Decennial Census data from 2000 and 2010 are also used to illustrate trends over time. No additional coordination with local and regional agencies or groups was necessary, as these available sources provide sufficient detail to permit the assessment and evaluation of impacts from the proposed action.

19.3.7.1 Population Characteristics

19.3.7.1.1 Population and Projected Growth in the Region of Influence

Population statistics for the ROI are shown in Table 19.3.7-1. The 2020 resident population of the ROI is 114,663. Between 2000 and 2020, the population of Gaines County, TX, experienced the greatest percentage increase in population within the ROI, at approximately 49 percent, while Lea County, NM, experienced the lowest increase at approximately 34 percent (Table 19.3.7-1). During this same period, the population of the ROI increased by approximately 38 percent, which is almost double the percentage increase of the state of New Mexico as a whole (16 percent), but slightly lower than the percentage increase of the population of Texas as a whole (40 percent).

Approximately 65 percent of the ROI resident population is located within Lea County, NM, while the remaining 35 percent are located in Andrews County, TX (16 percent), and Gaines County, TX (19 percent). While the ROI is largely rural, Lea County, NM, is the most populous

of the three counties, with several suburban areas such as the cities of Eunice, Hobbs, and Jal. Andrews and Gaines counties in Texas are more rural, each containing a single large municipality (Andrews and Seminole, respectively). Approximately 3.5 percent of the State of New Mexico's population resided in Lea County, and less than 1 percent of the population of the State of Texas resides in Andrews and Gaines counties.

Projected populations for the states of New Mexico and Texas are produced by the University of New Mexico's Geospatial and Population Studies and by the Texas Demographic Center, respectively (University of New Mexico, 2022; Texas Demographics, 2022). Projections are forecasted using existing datasets to determine estimated population, vital statics data (births and deaths), and predicted migration patterns (University of New Mexico, 2022; Texas Demographics, 2018). Projected population within the ROI from 2020 to 2070 is shown in Table 19.3.7-2. Within the ROI, the total population is expected to increase by approximately 308 percent by 2070, which is much greater than the projected increase for New Mexico (0.2 percent) and Texas (120 percent). Within the ROI, projected population increases between 2020 to 2070 are anticipated to be greatest within Andrews County, TX, at approximately 1439 percent. The population of Gaines County, TX, is projected to increase by approximately 236 percent while the population of Lea County, NM, is projected to increase by 46 percent.

19.3.7.1.2 Transient Population

The transient or seasonal population within 5.0 mi. (8 km) of the project site is negligible. The only major municipality within a 5.0-mi. (8-km) radius is the City of Eunice, which has a population of approximately 3000 individuals, representing approximately 4 percent of the total population of Lea County, NM. Additionally, no facilities that typically account for notable sources of transient population, such as colleges, universities, hospitals or large medical facilities, or tourist attractions, are located within the 5.0-mi. (8-km) radius.

19.3.7.2 Community Characteristics

19.3.7.2.1 Economic Characteristics

19.3.7.2.1.1 Employment, Jobs, and Occupational Patterns within the Region of Influence

Labor force and employment characteristics for the ROI are shown in Table 19.3.7-3. In 2020, the unemployment rate for the ROI was 5.8 percent, slightly lower than that of the State of New Mexico (6.5 percent) and slightly higher than that of the State of Texas (5.3 percent). As shown in Table 19.3.7-3, unemployment rates in the ROI were generally slightly lower in 2010 and slightly higher in 2000 compared to the unemployment rates in the States of New Mexico and Texas for those same years.

Employment by industry within the ROI is shown in Table 19.3.7-4. The largest percentage of the workforce in the ROI is employed in the following industry groups:

- Agriculture, forestry, fishing, hunting, and mining.
- Educational services, healthcare, and social assistance.

The largest percentage of workers in the States of Texas and New Mexico are employed in the educational services, healthcare, and social assistance industries; conversely, a much smaller percent of the workforce in the ROI work in the professional, scientific, management,

administrative, and waste management services industries as compared to employment within those industries.

19.3.7.2.1.2 Income

Income data for each county within the ROI, as well as New Mexico and Texas, are shown in Table 19.3.7-5. Per-capita income in the ROI ranged from $23,533 (Gaines County, TX) to $30,673 (Andrews County, TX) in 2020. Compared to per-capita income in each of the respective states, Gaines County, TX, has the lowest relative per-capita income (75.2 percent of the per capita income for the State of Texas) and Andrews County, TX, has the highest (98.1 percent of the per capita income for the State of Texas). Median household income was higher than state median household income for all counties within the ROI, ranging from 101.9 percent (Gaines County, TX) to 123.1 percent of the state-level median income (Andrews County, TX).

19.3.7.2.2 Tax Structure

19.3.7.2.2.1 Corporate Income Taxes

The New Mexico corporate income tax is applied to the taxable income of every domestic and foreign corporation doing business in or from New Mexico or which has income from property or employment within the state. The percentage of the taxable income apportioned and allocated to New Mexico is then applied to the gross tax. For taxable years beginning on January 1, 2020, or later, corporations with a total taxable income below $500,000 are taxed at 4.8 percent of the taxable income, and corporations with a total taxable income exceeding $500,000 annually are taxed at $24,000 plus 5.9 percent of net income over $500,000. New Mexico also has a corporate franchise tax of $50/yr (NMTRD, 2020).

Texas imposes a franchise tax on taxable entities formed or organized in Texas or doing business in Texas. The franchise tax, depending on the entity classification, ranges from 0.331 percent to 0.75 percent (TCPA, 2022a). A miscellaneous gross receipts tax is also imposed in Texas on utility companies that provide services within the state. The tax is based on the population of the incorporated area where the service is provided and ranges from approximately 0.6 percent to 2 percent (TCPA, 2022b).

19.3.7.2.2.2 Individual Income Taxes

New Mexico imposes a tax on the net income of every resident and on the net income of every nonresident employed or engaged in business in, into, or from the state or deriving any income from any property or employment within the state. The top tax bracket is 5.9 percent plus a standard dollar rate that varies depending on filing status and total taxable income. Currently, the standard rate ranges from $7513 to $15,027 (NMTRD, 2021). Personal income is not taxed in Texas.

19.3.7.2.2.3 Sales and Gross Receipts Tax

New Mexico does not have a sales tax but instead imposes gross receipts tax. This gross receipts tax is imposed on persons engaged in business in New Mexico. Although gross receipts tax is applied to the business, the business may pass the tax onto the purchaser. The gross receipts tax rate varies throughout the state, ranging from approximately 5.1 percent to 9.4 percent. It varies because the total rate combines rates imposed by the state, counties, and municipalities where each business is located (NMTRD 2022a). The gross receipts tax, effective

between January 1 and June 30, 2022, for communities in Lea County ranges from 5.5 percent to 7.4 percent (NMTRD, 2022b).

Texas imposes a state sales and use tax of 6.25 percent on all retail sales, leases, and rentals of most goods as well as taxable services. Local taxing jurisdictions (cities, counties, special purpose districts, and transit authorities) may impose up to 2 percent sales and use tax for a maximum combined rate of 8.25 percent (TCPA, 2022c).

19.3.7.2.2.4 Property Taxes

New Mexico property tax is a composite of taxes levied by the state, county, municipality, and school district. Millage (mill) rate, or effective property tax rate, is a multiplier attached to the value of a property and is used to calculate the local property taxes. It represents a dollar per thousand of a property's assessed value. In 2021, the State of New Mexico levied 1.360 mills to all counties, and Lea County levied 7.011 mills. Rates for municipalities ranged from 3.078 mills (Tatum) to 7.650 mills (Eunice). Rates for school districts ranged from 0.232 mills to 0.5 mills within each county depending on taxable property value. The total market value of property within Lea County is $7,334,490,186 (NMDFA, 2022).

Texas does not have a state property tax; however, local taxing units impose taxes to generate revenue to provide services such as schools, streets and roads, and police and fire protection. Rates for municipalities and school districts vary. For 2021, Andrews County, TX, had a county property tax rate of approximately $0.51 per $100 assessed value. The total market value of property in the county in 2021 was $5,135,322,301, and actual property taxes levied were $26,180,266. The total tax rate in 2020 for the school district in Andrews County (Andrews Independent School District) was $1.12 per $100 (TAC, 2022a). The county property tax rate for Gaines County in 2020 was approximately $0.55 per $100, the total market value of property was $3,641,701,122, and actual property taxes levied were $19,852,916. The total tax rate for the four school districts in Gaines County ranges from $1.23 per $100 to $1.41 per $100 (TAC, 2022b).

Property taxes paid for the EIPC project site were $5485.00 in 2021 and remained the same for 2022. Future property taxes on the project site would be determined based on the assessed value of the property, but at this time that value cannot be determined.

19.3.7.2.3 Housing

Housing characteristics in the ROI are shown in Table 19.3.7-6. In 2020, 39,723 housing units were present in the ROI, most of which are single-family homes. There are 5328 vacant housing units within the ROI, of which 1298 are for rent and 336 are for sale. Approximately 68 percent of the housing units in the ROI are located in Lea County, NM.

Table 19.3.7-7 shows estimated housing values for owner-occupied units in the ROI. The median value of houses in the ROI in 2020 ranged from $138,000 to $153,000. Approximately 34.8 percent of owner-occupied units within the ROI fall below a value of $100,000, whereas 62.5 percent have a value between $100,000 and $500,000. The median value of the remaining 2.7 percent of the housing units in the ROI is over $500,000.

19.3.7.2.4 Education

A total of 59 public and private elementary, middle, and high schools are located in the ROI, the majority of which are located in Lea County, NM. A summary of statistics for these schools, including student enrollment and student-to-teacher ratios for the 2019 – 2020 private school year and 2020 – 2021 public school year, is provided in Table 19.3.7-8. An estimate of the number of individuals within the ROI enrolled in school by grade level and post-secondary schooling is shown in Table 19.3.7-9. As shown in this table, during 2020, schools in the ROI served more than 30,000 students. The closest school to the project site is Caton Middle School (approximately 4.1 mi. [6.6 km] west of the project site center), followed by Eunice High School and Mettie Jordan Elementary School (both approximately 4.2 mi. (6.8 km) west of the project site center), as depicted on Figure 19.3.7-2.

Levels of education completed by individuals in the ROI are detailed in Table 19.3.7-10. The highest educational attainment for persons 25 years or older in the ROI is high school graduate (or equivalent) for approximately 32 percent, approximately 20 percent have attended some college, and approximately 21 percent have attained a college degree ranging from associates to doctorate degrees.

19.3.7.2.5 Healthcare, Public Safety, and Transportation Services

19.3.7.2.5.1 Water

As the entirety of the project site is located in Lea County, NM, it is anticipated that water services in Lea County service the EIPC. Lea County primarily obtains public water supply from groundwater, specifically from UWBs. The Lea County basin is approximately 2180 mi^2, (5646 km^2), and the primary aquifer is the Ogallala with a maximum saturated thickness of approximately 250 ft. (76 m). Within Lea County, the municipalities of Hobbs, Lovington, Eunice, Jal, and Tatum have water rights. These municipalities and other minor users have combined water rights of 48,035 ac-ft/yr (5925 hectare-meters [ha-m]/yr). The City of Eunice, the closest municipality to the project site (approximately 1.4 mi. [2.2 km] to the west) (Figure 19.3.7-2), has water rights of 3292 ac-ft/yr (406 ha-m/yr) (LCWUA, 2000). The Eunice water supply system serves approximately 2922 persons, uses approximately 423 gal. per capita, and withdraws approximately 1385 ac-ft/yr (107 ha-m/yr) (NMISC, 2016). The City of Eunice wastewater treatment plant is permitted to discharge approximately 400,000 gpd (NMISC, 2016).

19.3.7.2.5.2 Healthcare

Medical services in Lea County include the Hobbs Hospital in Hobbs, NM, which has 99 beds, provides intensive care, labor and delivery, orthopedics, and surgery outpatient services, and employs over 250 healthcare professionals (Covenant Health, 2022). In addition, the Lea County Hospital District operates multiple medical facilities, including the Nor-Lea General Hospital, a 25-bed facility. The hospital district employs over 450 full-time and part-time healthcare professionals and offers a multitude of specialties including oncology, cardiology, gastroenterology, occupational therapy, podiatry, rheumatology, and urology (Nor-Lea Hospital District, 2022). A health-care clinic in the City of Eunice specializes in family care (Trilogy Integrated Resources, 2022).

There is one hospital in Andrews County, TX: Permian Reginal Medical Center. The medical center has 34 beds and offers services for emergency care, surgery, physical therapy, radiology, and respiratory care (Permian Regional Medical Center, 2022). Seminole Memorial

Hospital is the only hospital in Gaines County, TX; it has 104 beds and offers services for cardiac therapy, surgery, physical therapy, radiology, and speech therapy (Seminole Hospital, 2022).

19.3.7.2.5.3 Public Safety

Emergency response to the EIPC is anticipated to be provided by the City of Eunice and more broadly Lea County, NM. The City of Eunice Police Department is a full-service law enforcement agency with 14 employees; it is located 4.6 mi. (7.4 km) west of the project site (Figure 19.3.7-2) (City of Eunice, 2022b). The Lea County Sheriff's office has 44 deputies and has resident deputies located in Eunice, NM (Town Square Publication, 2022).

The City of Eunice Fire and Rescue department has one station, two full-time firefighters, and 20 volunteer firefighters and is located approximately 3.7 mi. (6.0 km) west of the project site (Figure 19.3.7-2) (USA Fire Departments, 2022). Lea County, NM, has nine fire departments, including three volunteer fire departments. The volunteer fire departments include first responders, emergency medical technicians, hazardous materials response, and other qualified rescue personnel (Lea County, 2022c).

19.3.7.2.5.4 Transportation

The project site is located south of NM-176 and 1.5 mi. (2.4 km) east of NM-18. Currently, there is no developed access road to the project site. NM-176 is a two-lane rural roadway, and NM-18 is a four-lane divided highway classified as a minor arterial roadway. NM-18 connects to U.S. Highway 62/180 in Hobbs, NM (Bohannan, 2020).

Existing road conditions were evaluated in a 2020 traffic impact analysis. The average number of observed crashes per year along various stretches of NM-176 adjacent to the URENCO facility and the project site ranged from 0 to 3.2. The annual average daily traffic on NM-176 in 2019 was 4801 vehicles and 1311 trucks (Bohannan, 2020).

The nearest railroad to the project site is the Texas–New Mexico Railroad, owned by Permian Basin Railways, which passes through the City of Eunice. The railroad is approximately 104 mi. (167 km) long and has freight-docking facilities and warehouses in Hobbs, NM, and Lovington, NM. This railroad is primarily used for the hauling of oilfield chemicals and minerals, construction aggregates, and industrial waste and scrap (Iowa Pacific, 2022).

Three airports are located in Lea County, NM, in the cities of Hobbs, Lovington, and Jal. The Lea County Regional Airport in Hobbs is the only commercial airport, which is serviced by United Airlines and offers regional charter services.

19.3.7.2.6 Recreation

Within the three-county ROI, there are 35 recreation facilities (Table 19.3.7-11). The majority of these recreational facilities are municipal parks located within the cities of Hobbs, Eunice, and Jal (New Mexico) and Andrews and Seminole (Texas). These parks include pavilions, playground equipment, and sports fields. Within a 5-mi. (8-km) radius of the project site are two parks and one aquatics center (Figure 19.3.7-2). These recreation facilities include an outdoor pool, sports fields, multipurpose fields, paved trails, playgrounds, and picnic areas.

Table 19.3.7-1
Population in the Region of Influence (2000 – 2020)

Geography	2000	2010	2020	Percent Change 2000-2010	Percent Change 2010-2020	Percent Change 2000-2020
Lea County, NM	55,511	64,727	74,455	16.6%	15.0%	34.1%
Andrews County, TX	13,004	14,786	18,610	13.7%	25.9%	43.1%
Gaines County, TX	14,467	17,526	21,598	21.1%	23.2%	49.3%
ROI Total	**82,982**	**97,039**	**114,663**	**16.9%**	**18.2%**	**38.2%**
New Mexico	1,819,046	2,059,179	2,117,522	13.2%	2.8%	16.4%
Texas	20,851,820	25,145,561	29,145,505	20.6%	15.9%	39.8%

Source: USCB, 2000, 2010, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-2
Population Projections in the Region of Influence (2020 – 2040)

Geography	2020	2030	2040	2050	2060	2070	Percent Change 2030 – 2040	Percent Change 2040 – 2050	Percent Change 2020 – 2070
Lea County, NM[a]	74,455	80,093	86,405	93,214	100,561	108,486	7.9%	7.9%	45.7%
Andrews County, TX[b]	18,610	35,751	59,678	100,655	169,768	286,337	66.9%	68.7%	1438.6%
Gaines County, TX[b]	21,598	27,881	35,460	45,024	57,168	72,586	27.2%	27.0%	236.1%
ROI Total	**114,663**	**143,725**	**181,543**	**238,893**	**327,497**	**467,409**	**26.3%**	**31.6%**	**307.6%**
New Mexico[a]	2,117,522	2,136,414	2,132,755	2,129,102	2,125,456	2,121,816	-0.2%	-0.2%	0.2%
Texas[b]	29,145,505	34,894,452	40,686,496	47,342,105	55,086,457	64,097,651	16.6%	16.4%	119.9%

Source: University of New Mexico, 2022; Texas Demographics, 2022

a) For New Mexico and Lea County, a -0.2% and 7.9% growth rate per 10-year period, calculated based on the furthest published projections (2030 – 2040), is extrapolated to determine projections for 2050 – 2070.

b) For Texas and Andrews and Gaines counties, a 16.4%, 68.7%, and 27.0% growth rate per 10-year period, calculated based on the furthest published projections (2040 – 2050), is extrapolated to determine projections for 2060 – 2070.

Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-3
Labor Force and Employment Characteristics of the Region of Influence

	2020						
Geography	**Total Labor Force**	**Labor Force in Armed Services**	**Employed Civilian Labor Force**	**Unemployed Labor Force**	**Percent Unemployed Labor Force**	**2010 Percent Unemployed Labor Force**	**2000 Percent Unemployed Labor Force**
Lea County, NM	31,421	16	29,240	2165	6.9%	7.8%	8.8%
Andrews County, TX	9230	0	8868	362	3.9%	5.6%	8.2%
Gaines County, TX	8942	0	8601	341	3.8%	4.6%	5.5%
ROI Total	**49,593**	**16**	**46,709**	**2868**	**5.8%**	**6.9%**	**8.1%**
New Mexico	962,807	11,034	889,193	62,580	6.5%	7.2%	7.0%
Texas	14,309,066	94,824	13,461,358	752,884	5.3%	7.0%	5.7%

Source: USCB, 2000, 2010, 2020a
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-4
Employment by Industry in the Region of Influence (2020)

	Lea County, NM		Andrews County, TX		Gaines County, TX		ROI		New Mexico		Texas	
Industry	**Employees**	**Percent**	**Employees**	**Percent**	**Employees**	**Percent**	**Employees**	**Percent**	**Employees**	**Percent**	**Employees**	**Percent**
Agriculture, forestry, fishing and hunting, and mining	5489	18.8%	2101	23.7%	1783	20.7%	9373	20.1%	35,474	4.0%	382,157	2.8%
Construction	2500	8.5%	635	7.2%	1657	19.3%	4792	10.3%	64,253	7.2%	1,162,805	8.6%
Manufacturing	944	3.2%	552	6.2%	405	4.7%	1901	4.1%	35,522	4.0%	1,136,354	8.4%
Wholesale trade	1018	3.5%	224	2.5%	276	3.2%	1518	3.2%	15,938	1.8%	376,139	2.8%
Retail trade	3174	10.9%	888	10.0%	692	8.0%	4754	10.2%	99,088	11.1%	1,511,963	11.2%
Transportation and warehousing and utilities	2381	8.1%	569	6.4%	729	8.5%	3679	7.9%	38,845	4.4%	808,075	6.0%
Information	234	0.8%	69	0.8%	315	3.7%	618	1.3%	12,450	1.4%	227,404	1.7%
Finance and insurance, real estate, rental, and leasing	879	3.0%	277	3.1%	271	3.2%	1427	3.1%	42,483	4.8%	911,531	6.8%
Professional, scientific, administrative, and management services and waste management services	1658	5.7%	286	3.2%	221	2.6%	2165	4.6%	103,446	11.6%	1,576,600	11.7%
Educational services and healthcare and social assistance	5084	17.4%	1858	21.0%	1391	16.2%	8333	17.8%	228,325	25.7%	2,932,061	21.8%
Arts, entertainment, and recreation and accommodation and food services	2932	10.0%	941	10.6%	326	3.8%	4199	9.0%	96,220	10.8%	1,212,944	9.0%
Other services, except public administration	1509	5.2%	294	3.3%	285	3.3%	2088	4.5%	49,685	5.6%	680,503	5.1%
Public administration	1438	4.9%	174	2.0%	250	2.9%	1862	4.0%	67,464	7.6%	542,822	4.0%
Total	**29,240**	**100.0%**	**8868**	**100.0%**	**8601**	**100%**	**46,709**	**100.0%**	**889,193**	**100.0%**	**13,461,358**	**100.0%**

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-5
Income Data for Counties in the Region of Influence (2020)

	Lea County, NM	Andrews County, TX	Gaines County, TX	New Mexico	Texas
Per Capita Income	$25,585	$30,673	$23,533	$27,230	$31,277
Percent of State Per Capita Income	94.0%	98.1%	75.2%	--	--
Median Household Income	$60,546	$76,158	$63,054	$49,754	$61,874
Percent of State Median Household Income	121.7%	123.1%	101.9%	--	--

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence | CBG = census block group

Table 19.3.7-6
Housing Characteristics in the Region of Influence (2020)

	Lea County, NM	Andrews County, TX	Gaines County, TX	ROI
Total Housing Units	26,871	6347	6505	39,723
Units in Structure				
1 unit, detached	18,321	4450	4589	27,360
1 unit, attached	471	93	2	566
2 units	231	109	201	541
3 or 4 units	736	82	74	892
5 – 9 units	1000	135	86	1221
10 – 19 units	311	17	26	354
20 or more units	871	111	105	1087
Mobile home	4719	1324	1422	7465
Boat, RV, van, etc.	211	26	0	237
Occupancy				
Percent Occupied	85.1%	89.0%	90.4%	86.6%
Percent Vacant	14.9%	11.0%	9.6%	13.4%
Occupied Housing Units	22,868	5649	5878	34,395
Percent Owner Occupied	68.0%	74.7%	72.3%	69.8%
Percent Renter Occupied	32.0%	25.3%	27.7%	30.2%
Vacant Housing Units	4003	698	627	5328
For rent	1063	130	105	1298
Rented, not occupied	112	25	0	137
For sale only	267	36	33	336
Sold, not occupied	400	0	2	402
For seasonal, recreational, or occasional use	231	55	96	382
For migrant workers	110	0	2	112
Other vacant	1820	452	389	2661

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence | RV = recreational vehicle

Table 19.3.7-7
Value of All Owner-Occupied Housing Units in the Region of Influence (2020)

Value	Lea County, NM	Andrews County, TX	Gaines County, TX	ROI
Less than $50,000	2036	608	483	3127
$50,000 – $99,999	3252	885	1088	5225
$100,000 – $149,999	3202	524	629	4355
$150,000 – $199,999	2993	966	939	4898
$200,000 – $299,999	2783	728	704	4215
$300,000 – $499,999	815	449	291	1555
$500,000 – $999,999	465	39	114	618
$1,000,000 or more	9	21	0	30
Total Owner-Occupied Units	15,555	4220	4248	24,023
Median Value				
Median Value for All Owner-Occupied Housing Units	$138,600	$153,200	$141,200	--

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-8
Educational Facilities in the Region of Influence (2019 – 2020 and 2020 – 2021 School Year)

Geography	Total Number of Schools	Elementary	Middle	Secondary	Student Enrollment	Teachers (FTEs)[a]	Student-to-Teacher Ratio
Lea County, NM							
Eunice Municipal Schools	3	1	1	1	755	51.5	14.7
Hobbs Municipal Schools	18	13	4	1	9776	553.4	17.7
Jal Public Schools	3	1	1	1	472	32.0	14.8
Lovington Municipal Schools	10	6	2	2	3502	208.5	16.8
NM Corrections	1			1	10	0.5	20.0
Tatum Municipal Schools	3	1	1	1	329	22.5	14.6
Private Schools	4				268	28.9	9.3
Andrews County, TX							
Andrews ISD	6	3	1	2	4128	287.2	14.4
Gaines County, TX							
Loop ISD	1				146	17.3	8.5
Seagraves ISD	1				510	46.0	11.1
Seminole ISD	6	3	1	2	2928	75.2	38.9
Private Schools	3				605	56.5	10.7
ROI Totals	**59**				**23,429**	**1379.5**	**17.0**

Source: NCES, 2022
a. FTE = Full-time equivalent employee (part-time workers are reported as a fraction of one full-time worker).
Abbreviations: NM= New Mexico | TX = Texas | FTE = full-time equivalent | ISD = independent school district | ROI = region of influence

Table 19.3.7-9
Enrollment by Level of School in the Region of Influence (2020)

Enrollment Level	Lea County, NM	Andrews County, TX	Gaines County, TX	ROI
Nursery school, preschool	910	264	562	1736
Kindergarten	1088	347	184	1619
Grade 1 to Grade 4	5133	1260	1870	8263
Grade 5 to Grade 8	4998	1271	1395	7664
Grade 9 to Grade 12	4237	1250	934	6421
College, undergraduate years	2759	937	362	4058
Graduate or professional school	384	33	79	496
Total	**19,509**	**5362**	**5386**	**30,257**

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-10
Level of Educational Attainment in the Region of Influence for Persons 25 and Older (2020)

	Lea County, NM		Andrews County, TX		Gaines County, TX		ROI	
Level of Schooling	**Residents 25 Years and older**	**Percent of Total**	**Residents 25 Years and older**	**Percent of Total**	**Residents 25 Years and older**	**Percent of Total**	**Residents 25 Years and older**	**Percent of Total**
No Schooling Complete	1017	2.4%	277	2.5%	894	7.9%	2188	3.4%
Nursey – Grade 12 (no diploma)	9303	22.0%	2272	20.8%	3438	30.3%	15,013	23.3%
High school graduate (includes equivalency)	13,524	32.0%	3656	33.4%	3666	32.3%	20,846	32.3%
Some college, less than 1 year and more than 1 year, no degree	8886	21.0%	2292	20.9%	1572	13.9%	12,750	19.8%
Associate's degree	3343	7.9%	813	7.4%	581	5.1%	4737	7.3%
Bachelor's degree	3467	8.2%	1194	10.9%	836	7.4%	5497	8.5%
Master's degree	2257	5.3%	288	2.6%	313	2.8%	2858	4.4%
Professional school degree	294	0.7%	99	0.9%	35	0.3%	428	0.7%
Doctorate degree	142	0.3%	53	0.5%	0	0.0%	195	0.3%
Total	**42,233**	**100%**	**10,944**	**100%**	**11,335**	**100%**	**64,512**	**100%**

Source: USCB, 2020b
Abbreviations: NM = New Mexico | TX = Texas | ROI = region of influence

Table 19.3.7-11
Recreation Facilities within the Region of Influence

Facility Name	County	Distance from Project Site (mi.)
Municipal Park	Lea County, NM	3.8
Eunice Aquatic Center	Lea County, NM	3.9
Marshall Park	Lea County, NM	3.9
Heizer Park	Lea County, NM	18.0
Heizer Pool	Lea County, NM	18.1
Acre Sports Park	Lea County, NM	18.3
Washington Park	Lea County, NM	18.8
Bender Park	Lea County, NM	19.2
City Park	Lea County, NM	19.5
Bensing Park	Lea County, NM	19.8
Humble Park	Lea County, NM	19.9
Green Acres Park	Lea County, NM	20.1
North Park	Lea County, NM	21.6
Del Norte Aquatic Facility	Lea County, NM	22.5
5th Street Park	Lea County, NM	22.6
Jal Lake Park	Lea County, NM	23.0
Henry McAdams Park	Lea County, NM	24.9
Florey Park	Andrews County, TX	30.8
Heritage Park	Andrews County, TX	31.4
Gaines County Veterans Memorial Park	Gaines County, TX	31.7
S.S. Forest Park	Gaines County, TX	32.0
Tri Corners Park	Gaines County, TX	32.2
B & B Park	Andrews County, TX	32.3
Lakeside Park	Andrews County, TX	32.4
Lincoln Park	Andrews County, TX	32.8
Wetland Park	Andrews County, TX	33.1
MS Doss City Park	Gaines County, TX	33.2
Pioneer Park	Gaines County, TX	33.2
Steve Haley Park	Gaines County, TX	33.5
Andrews Bird Trail/Nature Path	Andrews County, TX	33.8
Chaparral Park	Lea County, NM	38.2
Lea County Fairgrounds	Lea County, NM	38.8
Seagraves Walking Park	Gaines County, TX	46.6
Travis Bagley Park	Gaines County, TX	47.6
City Park	Lea County, NM	58.9

Source: Lea County, 2013 and USGS, 2022f
Abbreviations: mi. = mile(s) | NM = New Mexico | TX = Texas

19.3.8 HUMAN HEALTH

This section summarizes the public and occupational health issues at the EIPC and the surrounding region, including locations where populations could live and work within the vicinity of the EIPC and other sources of radiation or chemical exposure. Applicable radiation dose limits, which have been established for the protection of the public and occupational health and safety, potential exposure pathways and receptors, and available occupational and public health studies are also described.

The sources of radiation exposure considered at the EIPC and in the surrounding region have both natural and manmade origins. These include background radiation and radiation from other sources such as nearby facilities or transportation infrastructure.

19.3.8.1 Map of Potential Sensitive Surrounding Facilities

Figure 19.3.8-1 shows the distances from the project site to the following potential sensitive receptors:

- Nearest full-time resident, located 1.7 mi. (2.7 km) west-northwest.
- Nearest groundwater system, located 1.3 mi. (2.1 km) northeast (URENCO #NM3501013).
- Nearest municipal water supply system, located 18.5 mi. (29.8 km) north-northwest (Eunice Water Supply System #NM3521513).
- Nearest school, located 4.1 mi. (6.6 km) west-northwest (Caton Middle School).
- Nearest medical facility, located 3.9 mi. (6.3 km) west-northwest (Eunice Health Clinic).
- Nearest assisted living facility, located 19.1 mi. (30.7 km) north-northwest (Landmark at Desert Gardens).

19.3.8.2 Background Radiation Exposure

The major sources and levels of background radiation exposure, both natural and manmade, are discussed in this subsection. Radiation exposure, or dose, is a measure of the amount of ionizing energy that is deposited in the body. Ionizing radiation is a natural component of the environment and ecosystem, and the public is exposed to natural radiation on a continuous basis. The National Council on Radiation Protection (NCRP) estimates that the average dose rate to the public from all natural background radiation sources is 3.1 millisieverts (mSv)/yr (310 millirem [mrem]/yr) (NCRP, 2009). With the manmade radiation, the average dose to the public from all sources (natural and manmade) is 6.2 mSv/yr (620 mrem/yr) (NCRP, 2009).

The highest average annual preoperational radiation dose that ISP documented in the ER from prior monitoring near the proposed CISF project area was 0.168 mSv (16.8 mrem). This dose is based on quarterly readings WCS obtained in 2010 from dosimeters placed at locations at and near the location of the current WCS facility, near the EIPC, as part of a preoperational monitoring program. For context, this measured dose is slightly less than the U.S. average annual terrestrial radiation dose of 0.21 mSv (21 mrem) (NCRP, 2009) and is, therefore, generally consistent with the NRC's expectations for background radiation (NUREG-2239).

19.3.8.2.1 Natural Sources

The NRC designates natural sources of radiation in three categories: cosmic, internal, and terrestrial. Cosmic radiation results from extraterrestrial sources, such as the sun and other stars, that penetrate the Earth's atmosphere. Internal radiation is the result of naturally occurring potassium-40 (K-40) and carbon-14 (C-14) in all humans. Terrestrial radiation is the result of dose received from naturally occurring U, thorium (Th), and radium (Ra) found in soil and rock. Also, radon (Rn) gas seeps through the ground and into the air where it is inhaled; this source represents the majority of the background radiation experienced by the average person exposed to it (NCRP, 2009).

Based on information as presented and cited in the following subsections, natural features near the EIPC align with the average features in the United States, and the natural background radiation is expected to be near the national average; therefore, the public is expected to receive an annual average natural background dose of 3.1 mSv/yr (310 mrem/yr) (NCRP, 2009). This aligns with the NRC's annual natural background dose estimate for the nearby CISF site (NUREG-2239).

19.3.8.2.1.1 Cosmic Radiation

The average annual dose due to cosmic radiation in the United States is 0.33 mSV (33 mrem) (NCRP, 2009). Cosmic radiation exposure increases with the site elevation and, for the EIPC site, an additional 0.10 mSV/yr to 0.15 mSV/yr (10 mrem/yr to 15 mrem/yr) is estimated due to elevation based on a recent assessment prepared for the USEPA (SCA, 2005). Note that the EIPC site elevation is approximately 3373 ft. (1028 m) NAVD 88 as provided by the USGS (2021b). The overall total annual dose due to cosmic radiation remains relatively small; therefore, it is appropriate to use the national average values as an approximation for the EIPC.

19.3.8.2.1.2 Internal Radiation

Internal radiation is mainly due to radioactive K-40 and C-14 contained inside the human body. The average annual dose due to internal radiation in the United States is approximately 0.29 mSv (29 mrem) (NCRP, 2009). This average value was found to be an acceptable approximation for the nearby CISF site by NRC (NUREG-2239); therefore, 0.29 mSv/yr (29 mrem/yr) is a valid internal radiation dose rate at the EIPC.

19.3.8.2.1.3 Terrestrial Radiation

Terrestrial radiation is mainly due to radioactive materials (including U, Th, and Ra) that exist naturally in soil and rock. The average annual dose due to terrestrial radiation in the United States is approximately 0.21 mSv (21 mrem) (NCRP, 2009). The annual average dose contribution due to Rn and thoron is an additional 2.28 mSv (228 mrem) (NCRP, 2009). The total average value was found to be an acceptable approximation for the nearby CISF site by NRC (NUREG-2239); therefore, 2.49 mSv/yr (249 mrem/yr) is a valid terrestrial radiation dose rate at the EIPC.

19.3.8.2.2 Manmade Sources

Manmade radiation derives from medical sources, consumer product sources, nuclear power sources, and occupational sources. Medical sources (e.g., diagnostic X-rays, whole-body computerized tomography [CT] scans, and nuclear medicine procedures) account for a vast

majority of the manmade radiation dose received annually. Consumer products (e.g., combustible fuels, televisions, smoke detectors, and tobacco) also contribute to the manmade radiation dose. In addition, the nuclear fuel cycle (from U mining and milling to disposal of spent fuel), the transportation of radioactive materials, and the fallout from nuclear weapons testing and reactor accidents also contribute to manmade radiation dose. Lastly, occupational sources (e.g., industrial radiography and research laboratories) contribute as well (NRC, 2020).

Based on the information as presented and cited in the following subsections, there are no significant abnormal sources of manmade background radiation in the vicinity of the EIPC; therefore, the public is expected to receive an average annual dose due to manmade radiation sources of 3.1 mSv (310 mrem) in the vicinity of the EIPC. This average value was found to be an acceptable approximation for the nearby CISF site by the NRC (NUREG-2239).

19.3.8.2.2.1 Medical Sources

The area surrounding the EIPC site contains five medical facilities. Three of the medical facilities are in New Mexico: Hobbs Hospital in Hobbs, Nor-Lea Hospital District in Lovington, and Eunice Health Clinic in Eunice. The other two medical facilities are in Texas: the Seminole Hospital District in Seminole and the Permian Regional Medical Center in Andrews. While Hobbs Hospital and Eunice Health Clinic do not provide services that utilize ionizing radiation, the other three hospitals have radiology departments and provide medical services that, at a minimum, include imaging services.

The staff at hospitals with radiology departments may receive a higher dose due to medical sources than the average person. The national average annual dose due to medical sources is 3.0 mSv (300 mrem) (NCRP, 2009). Note that medical workers are not expected to receive a dose rate in excess of the occupational limit set in 10 CFR Part 20, 0.05 sieverts per year (5 rem/yr).

19.3.8.2.2.2 Consumer Products

Ionizing radiation dose from the use of consumer products fluctuates based on the lifestyle of a given individual; therefore, a best estimate of the average annual dose due to consumer products, 0.13 mSv (13 mrem), is used (NCRP, 2009).

19.3.8.2.2.3 Nuclear Fuel-Cycle Facilities

The region surrounding the proposed EIPC includes other facilities that involve radioactive materials, including the URENCO Facility in Lea County, NM, and the WCS site in Andrews County, TX (NUREG-2239). The estimated or measured maximum operational radiological doses to the public from these facilities are described in the following paragraphs. The contribution to manmade radiation from these facilities to the EIPC is small and relatively insignificant compared with the total average dose due to manmade radiation sources. In addition, because the EIPC is located 0.5 mi. (0.8 km) south of NM-176 and slightly less than 2 mi. (3.2 km) east of NM-18, there may be some radiation received from the transportation of radioactive material along these roadways.

URENCO is located approximately 1.3 mi. (2.1 km) northeast of the EIPC site. The URENCO facility enriches U using a gas centrifuge process. The enriched U is used in the manufacture of nuclear fuel for commercial nuclear power reactors. The environmental impacts of the URENCO operations are documented in NUREG–1790. Impacts related to radiation exposure include

small public and occupational health and transportation impacts during normal operations and small-to-moderate public and occupational health and transportation impacts under evaluated accident conditions. In that analysis, the highest estimated annual public dose from normal facility operations was 0.19 mSv (19 mrem). A recent semiannual radiological effluent release report, submitted to the NRC applicable to operations during the first half of 2019, documented that concentrations of gross alpha radioactivity, gross beta radioactivity, and U isotopes in monitored liquid and airborne effluents at the discharge points were either below minimum detectable concentrations or less than 10 percent of the applicable concentration limits in 10 CFR Part 20, Appendix B (NUREG-2239).

The WCS operates two facilities authorized to dispose mixed Class A, B, and C LLW approximately 2.6 mi. (4.2 km) northeast of the EIPC, with the planned CISF in the future. The two facilities are referred to as the Compact Waste Disposal Facility (CWF) and Federal Waste Disposal Facility (FWF). The CWF serves the Texas LLW compact (Texas and Vermont) and the FWF serves the U.S. federal government. The WCS also operates a facility authorized to dispose of Atomic Energy Act Section 11e.(2) byproduct material. Annual radiological doses to the public from existing WCS facility operations are documented every six months in a semiannual Radiological Environmental Monitoring Program (REMP) report. The WCS REMP report for 2014 operations documented the annual estimated public dose at 0.027 mSv (2.7 mrem) (NUREG-2239).

19.3.8.3 Description of Radioactive and Nonradioactive Liquid, Gaseous, and Solid Waste Management Effluent Control Systems

No radioactive or nonradioactive materials are currently stored within the project site; therefore, no radioactive or nonradioactive effluent control systems are currently present on or within the EIPC project site.

19.3.8.4 Information on Radioactive and Nonradioactive Effluents Released to the Environment

No radioactive or nonradioactive materials are stored on the project site; therefore, there are no radioactive or nonradioactive effluents released from the existing site.

Subsection 19.3.8.2 provides a discussion of radioactive releases from nearby operating nuclear reactor facilities.

19.3.8.5 Radioactive and Nonradioactive Hazardous Material Stored On-site or within the Vicinity

No radioactive materials are currently stored on the project site. See Subsection 19.3.8.2.2.3 for a discussion related to other nuclear fuel cycle facilities near the EIPC project site. Subsection 19.3.8.7 presents information regarding nearby sources of chemical exposure.

19.3.8.6 Current On-site or Nearby Sources and Levels of Exposure to Members of the Public and Workers from Radioactive Materials

No existing radioactive materials are currently stored at the project site; therefore, no associated exposure to the public exists. Subsection 19.3.8.2.2.3 provides a discussion related to exposure due to other nuclear fuel cycle facilities near the EIPC.

19.3.8.7 Major Sources and Levels of Chemical Exposure

The project site has no known history of use as an industrial site; consequently, no known major sources of chemical exposure exist at the project site that may impact the public.

The USEPA Envirofacts Multisystem Search Form allows users to search multiple environmental databases for facility information, including toxic chemical releases, water discharge permit compliance, hazardous waste handling processes in compliance with the Resource Conservation and Recovery Act, Superfund status, and air emission estimates. USEPA's Enforcement and Compliance History Online (ECHO) tool within Envirofacts allows users to access integrated data from a variety of USEPA data systems. A search within a 10-mi. (16.1-km) radius of the project site was conducted using the Envirofacts and ECHO database systems to identify potential sources of chemicals that may represent a potential for exposure to the public. This review identified one facility included within the database. Site information and reporting information were reviewed for the facility identified as WCS in Andrews, TX; however, no data pertaining to chemical storage were provided (USEPA, 2022f). The only violations reported for the WCS facility pertained to the non-submission of discharge monitoring reports (USEPA, 2022g).

The Toxics Release Inventory (TRI) was established under the Emergency Planning and Community Right-to-Know Act of 1986. Releases reported to the TRI from facilities in the vicinity of the project site are indicative of storage, use, and/or production of the reported contaminants at a facility. WCS was the only facility located within a 10-mi. (16.1-km) radius of the project site (searched as Andrews Highway, Eunice, NM 88231) that reported releases in 2020 (USEPA, 2022h). Airborne releases from the WCS facility are a potential source of chemical exposure.

The TRI data described herein indicate that reported air emissions in the general vicinity of the project site included bromine, cadmium, chlorine, copper, lead, mercury, and polychlorinated biphenyls, all of which are inhalation toxicants or respiratory irritants that may contribute to regional health conditions (USEPA, 2022h, 2022i, 2022j, 2022k, 2022l; NIOSH, 2022a; CalEPA, 2022a, 2022b).

19.3.8.8 Historical Exposures to Radioactive Materials to Members of the Public and Workers

There are no recordable incidents involving radioactive material at the EIPC project site.

19.3.8.9 Description of Radiological Monitoring Programs at Nearby Operating Facilities

As discussed in Subsection 19.3.8.2.2.3, the URENCO and WCS sites are nuclear fuel-cycle facilities near the EIPC. Both sites have REMPs, as discussed below. In addition, the environmental report submitted by the ISP for the nearby CISF provides an estimated cumulative dose rate to a maximally exposed individual (MEI) from the surrounding nuclear-related facilities, including those from URENCO and WCS facilities (ISP, 2020). The ISP estimated the total MEI dose rate to be approximately 0.0028 mSv/yr (2.8 mrem/yr), a value that is relatively insignificant compared to the background radiation exposure levels discussed in Subsection 19.3.8.2.

19.3.8.9.1 Nuclear Enrichment Facility Radiological Environmental Monitoring Program

The URENCO REMP is overseen by the facility's Quality Assurance Program and, as such, employs written procedures for all aspects of sampling, analysis, and reporting. These procedures ensure that measurement systems are calibrated and in proper working order and that accurate and high-quality measurement data are produced. URENCO is required to submit a semiannual radiological effluent release report to the NRC. This report must indicate the quantities of specific radionuclides released to unrestricted areas in liquid and gaseous effluents over the previous six months and assess environmental performance against applicable NRC regulations (NRC, 2015).

Initial monitoring under the REMP included the determination of site baseline conditions prior to June 2010, when enrichment operations began at the site. The site baseline conditions are compared with data collected during operations to assess potential radiological impacts to the public and compliance with radiation protection standards (NRC, 2015).

Gaseous effluents are monitored using continuous air particulate samplers on the various effluent vent stacks. Filters are analyzed for gross alpha and gross beta activity weekly and for isotopic U quarterly. Air monitoring of the site employs airborne particulate filter samplers arrayed around the facility, which are also analyzed for gross alpha and gross beta activity biweekly and for specific U isotopes quarterly. In addition, water and sediment samples are collected periodically and are subjected to isotopic U analysis. The sanitary sewage system is similarly periodically analyzed for isotopic U. Soil, vegetation, and groundwater samples from an array of wells are also sampled periodically and compared to baseline levels (NRC, 2015).

The program also measures direct radiation levels produced from radioactive materials on-site. Environmental thermoluminescent detectors (TLDs) are placed along the perimeter fence line and other locations to detect a measurable radiation dose. Estimates of potential doses to the public, needed for compliance with applicable health protection standards, are performed using a computer model and the data from these direct, on-site dose measurements (NRC, 2015).

19.3.8.9.2 Waste Control Specialists Radiological Environmental Monitoring Program

WCS conducts a comprehensive environmental sampling and analysis program, commonly referred to as the consolidated REMP. Routine monitoring of work areas gives an early indication of potential environmental concerns. The REMP serves as a primary confirmation of the adequacy of the active operational controls and the passive engineering and burial site controls for preventing releases beyond the design basis for the facilities. This program also provides environmental data to demonstrate compliance with radioactive effluent release standards contained in 10 CFR Part 20, Appendix B. The WCS facility REMP encompasses procedures and planning documents addressing the types, frequency, and methodologies employed to acquire the requisite data.

As part of the REMP, samples of media and effluents, including gases and vapor, air particulates, soil, sediment, fauna, vegetation, surface water, wastewaters, and groundwater, are collected and analyzed. A monitoring network of TLDs and optically stimulated luminescence detectors are also used to measure ambient gamma radiation. The sampling media and sampling locations included in the REMP provide a measure of the routine operations within and around the facility and monitor the potential impact of the facility operations on the off-site environment, including the general public. Sampling locations are selected to serve as operational, early warning, and off-site environmental indicators.

19.3.8.10 Occupational Injury and Operational Fatality Rates

Occupational injury and fatal injury rates for occupations relevant to the construction, operation, and decommissioning of the EIPC are discussed in this subsection.

Recent data from the U.S. Bureau of Labor Statistics (BLS), which list incidence rates of nonfatal occupational injuries and illnesses by industry, were reviewed to estimate relevant occupational injury rates to provide a context for analysis of potential project impacts. The incidence rate is defined as the number of recordable cases per 100 full-time workers (BLS, 2022a). For this estimate, the incidence rate of the total number of recordable cases was used.

During the operation phase of the EIPC, employees work in environments found in multiple industries, so the incidence rate across all private industries was used. The national incidence rate of recordable cases across all private industries in 2020 was 2.7 cases per 100 full-time workers. Similarly, the rate of recordable cases was 2.6 cases per 100 full-time workers for New Mexico in 2020 and 2.0 cases per 100 full-time workers for Texas in 2020. The 2020 incidence rates for nonfatal occupational injuries to construction workers were 2.5 cases per 100 full-time workers nationally, 2.0 cases per 100 full-time workers in New Mexico, and 1.5 cases per 100 full-time workers in Texas (BLS, 2022a, 2022b, 2022c).

Comparable BLS data exist for occupational fatal injury rates. Fatal injury rates are defined by the BLS as the number of fatal occupational injuries per 100,000 full-time equivalent workers. The national average fatality rate across all private industry in 2020 was 3.7 per 100,000 full-time equivalent workers, in New Mexico it was 4.6 per 100,000 full-time equivalent workers, and in Texas it was 3.9 per 100,000 full-time equivalent workers. The national average fatality rate for construction workers in 2020 was 10.2 fatalities per 100,000 full time equivalent workers. New Mexico construction worker fatality rates were not reported by BLS in 2020. The fatality rate for construction workers in Texas in 2020 was 12.0 fatalities per 100,000 full time equivalent workers (BLS, 2022d, 2022e).

19.3.8.11 Public and Occupational Exposure Limits

The accident dose criterion for radiation dose to an individual member of the public is 1.0 rem, total effective dose equivalent (TEDE) to the whole body. This is applied at the 500-m (1640-ft.) site boundary or, alternatively, at the maximum dose exposure distance from the facility for a member of the public. For the occupational worker, the TEDE dose limit is 5 rem, or 50 rem committed dose equivalent to any individual organ or tissue other than the lens of the eye. These dose limits are established by 10 CFR 50.34(a)(1)(i); 10 CRF Part 20.1301; and 10 CFR 20.1201. .

19.3.8.12 Summary of Relevant Health Effects Studies

The National Institute for Occupational Safety and Health (NIOSH), a division of the Centers for Disease Control and Prevention, maintains the Health Hazard Evaluation (HHE) Program to assist stakeholders in learning whether health hazards are present at their workplace and recommend ways to reduce hazards and prevent work-related illness.

A search of the NIOSH HHE database identified 16 HHE reports published nationwide that included workplace evaluations where molybdenum was a chemical of potential concern. No documented health effects associated with potential molybdenum exposure were identified (NIOSH, 2022b).

A search of the NIOSH HHE identified 22 records published for facilities in New Mexico. No HHEs were identified that were relevant to the workplace activities that are undertaken at the EIPC (NIOSH, 2022c). NIOSH did publish HHEs in New Mexico for facilities handling U and for potential chemical exposures in general workplace, laboratory, and medical settings, but none of those HHEs were specific to potential radionuclide exposure from either production or use during medical testing.

A search of the NIOSH HHEs identified 88 records published for facilities in Texas. No HHEs were identified that were relevant to the workplace activities that are undertaken at the EIPC (NIOSH, 2022d). NIOSH did publish HHEs in Texas for potential chemical exposures in general workplace, laboratory, and medical settings, but none of those HHEs were specific to potential radionuclide exposure from either production or use during medical testing.

The NIOSH HHE database was searched for nuclear medicine isotopes described in Section 19.2 (i.e., lutetium, ruthenium, U, and xenon) and for chemicals listed in Section 19.2 that are used to process 2000 targets (i.e., acetohydroxamic acid, tributyl phosphate, sulfuric acid, nitric acid, sodium hydroxide, alpha benzoin oxime, hydrochloric acid, hydrogen peroxide, potassium permanganate, rhodium chloride trihydrate, silver nitrate, and sodium iodide). This search identified 249 records published nationally, including potential chemical exposures in general workplace, laboratory, and medical settings, but none of those HHEs were specific to potential exposure from either radionuclide production or use during medical testing (NIOSH, 2022e).

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Figure 19.3.1-1
EIPC Project Site

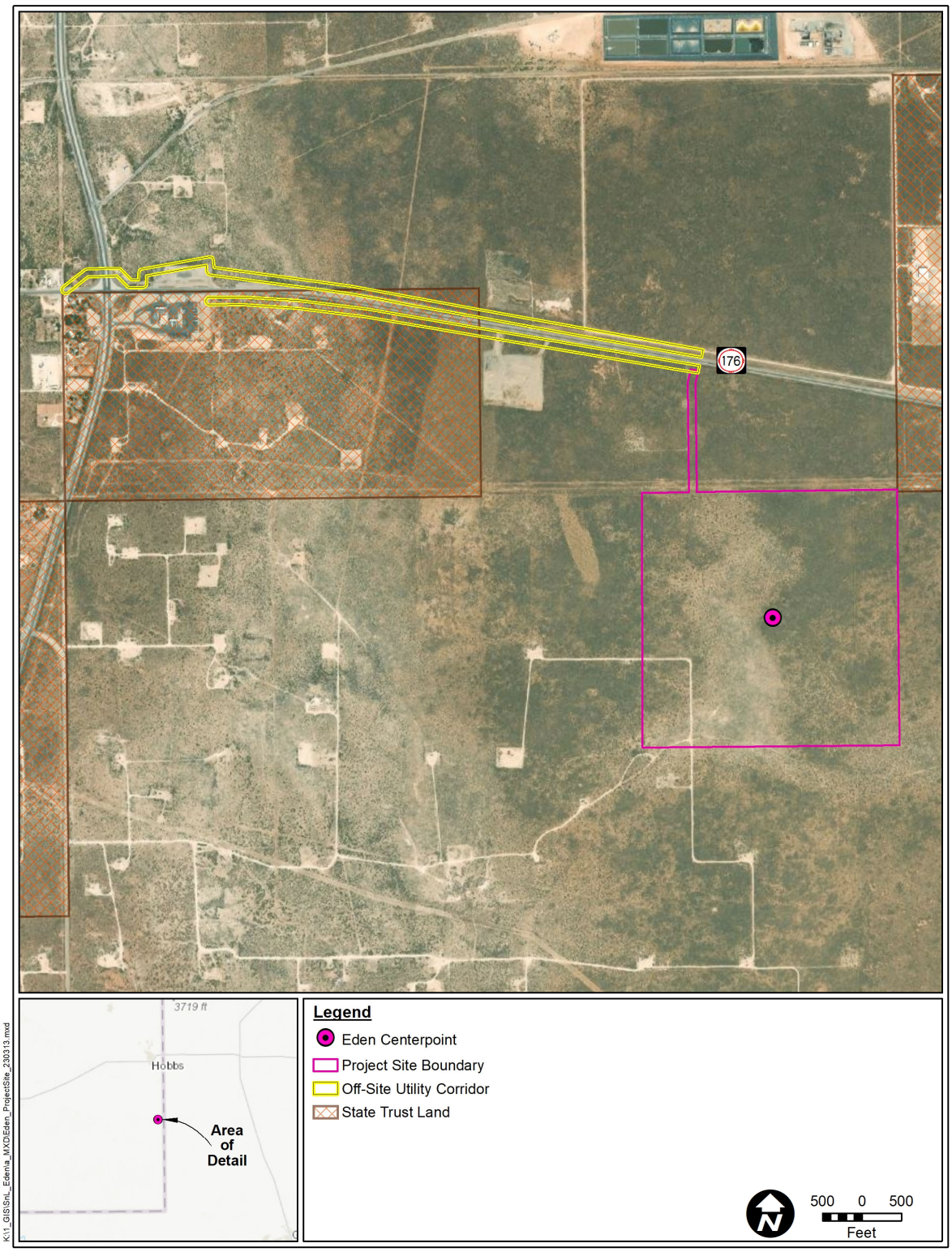


Figure 19.3.1-2
Land Use/Land Cover within the Project Site and Region

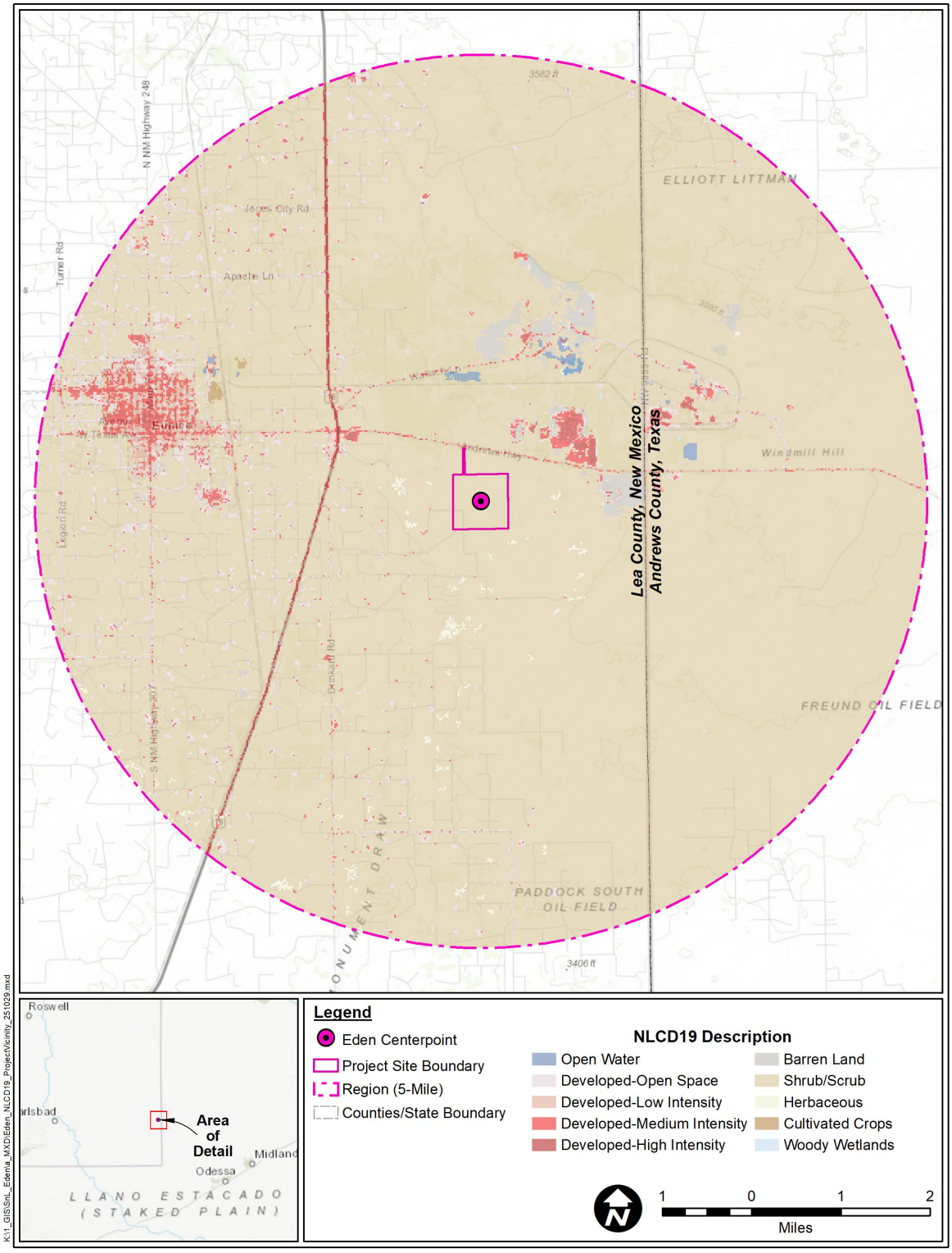


Figure 19.3.1-3
Major Population Center and Infrastructure within the Region

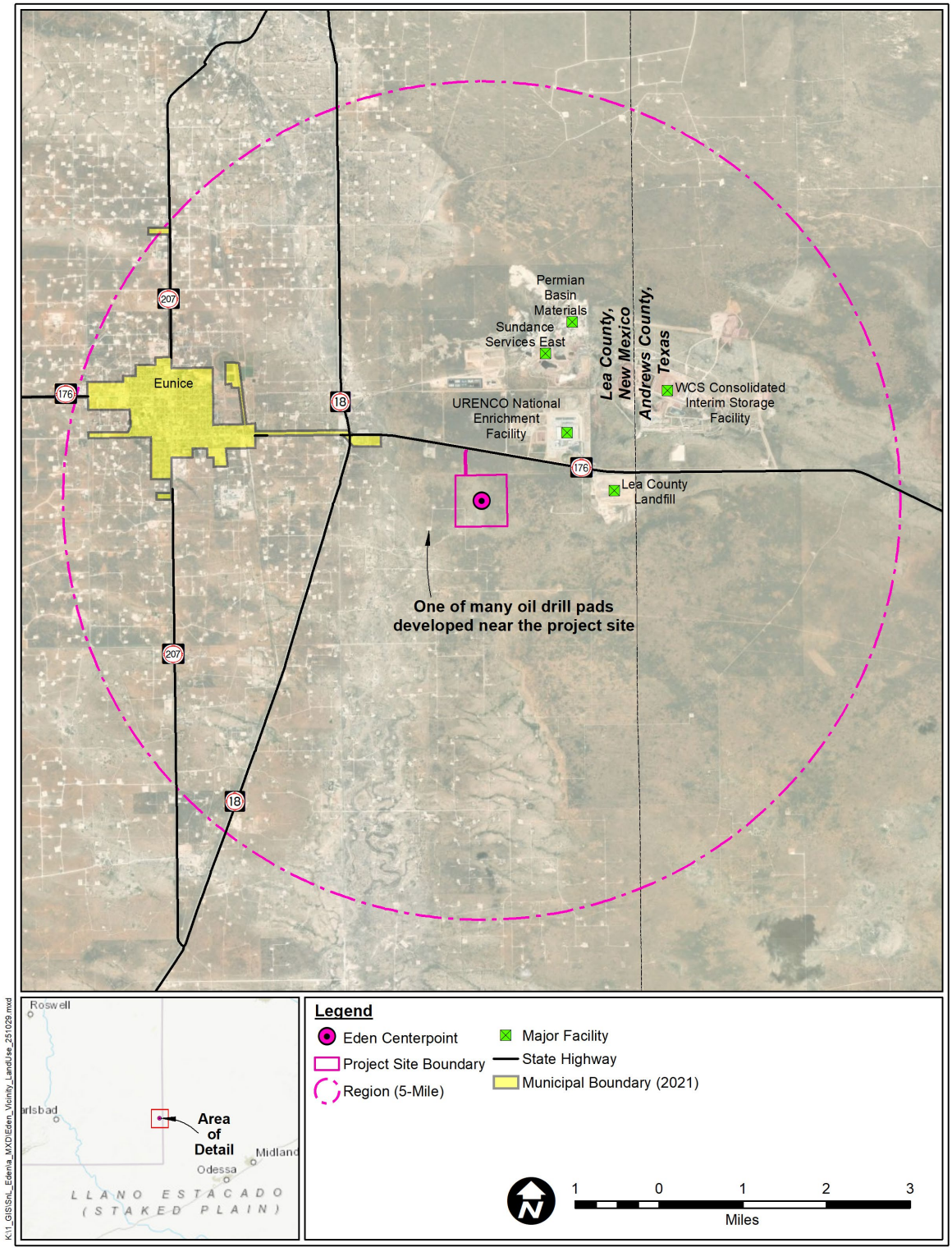
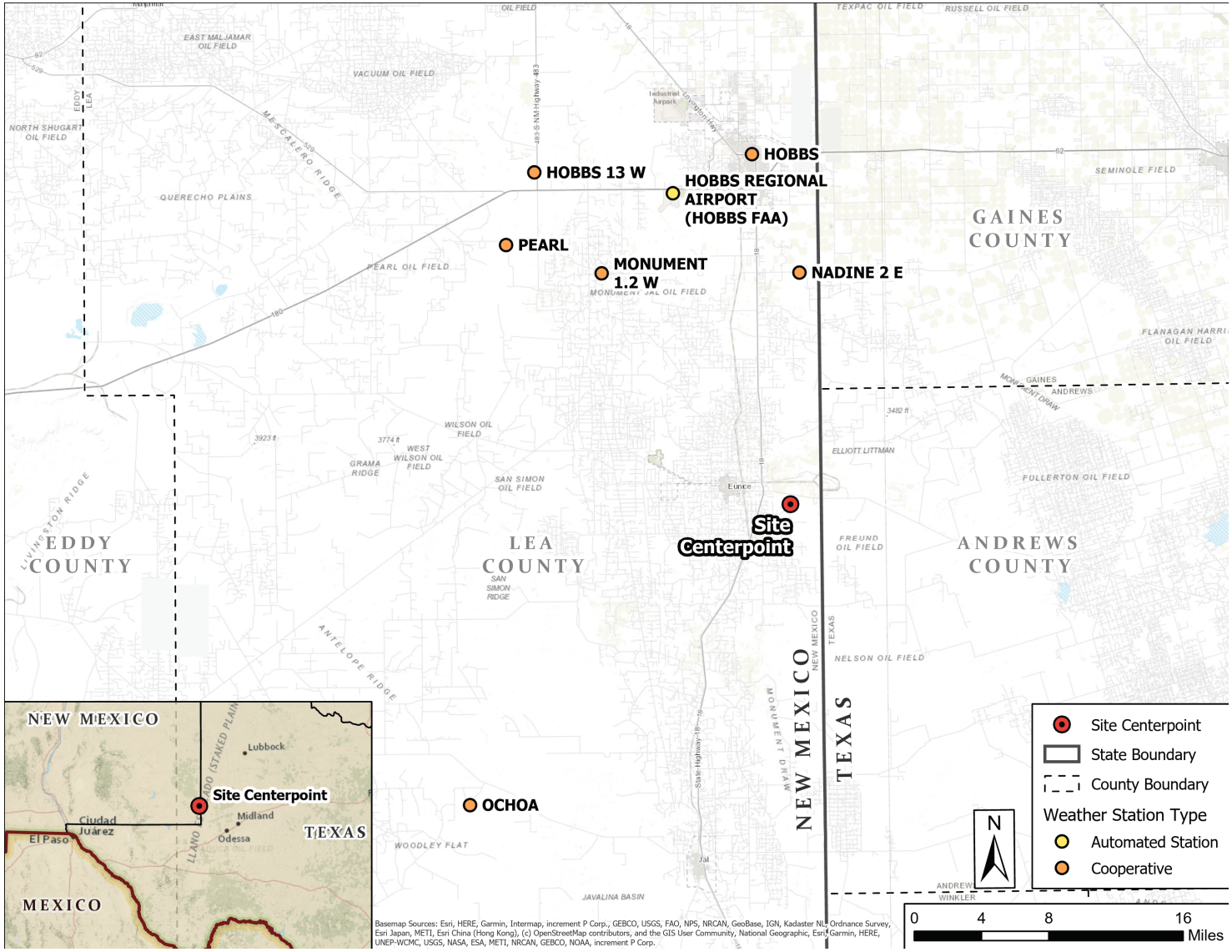
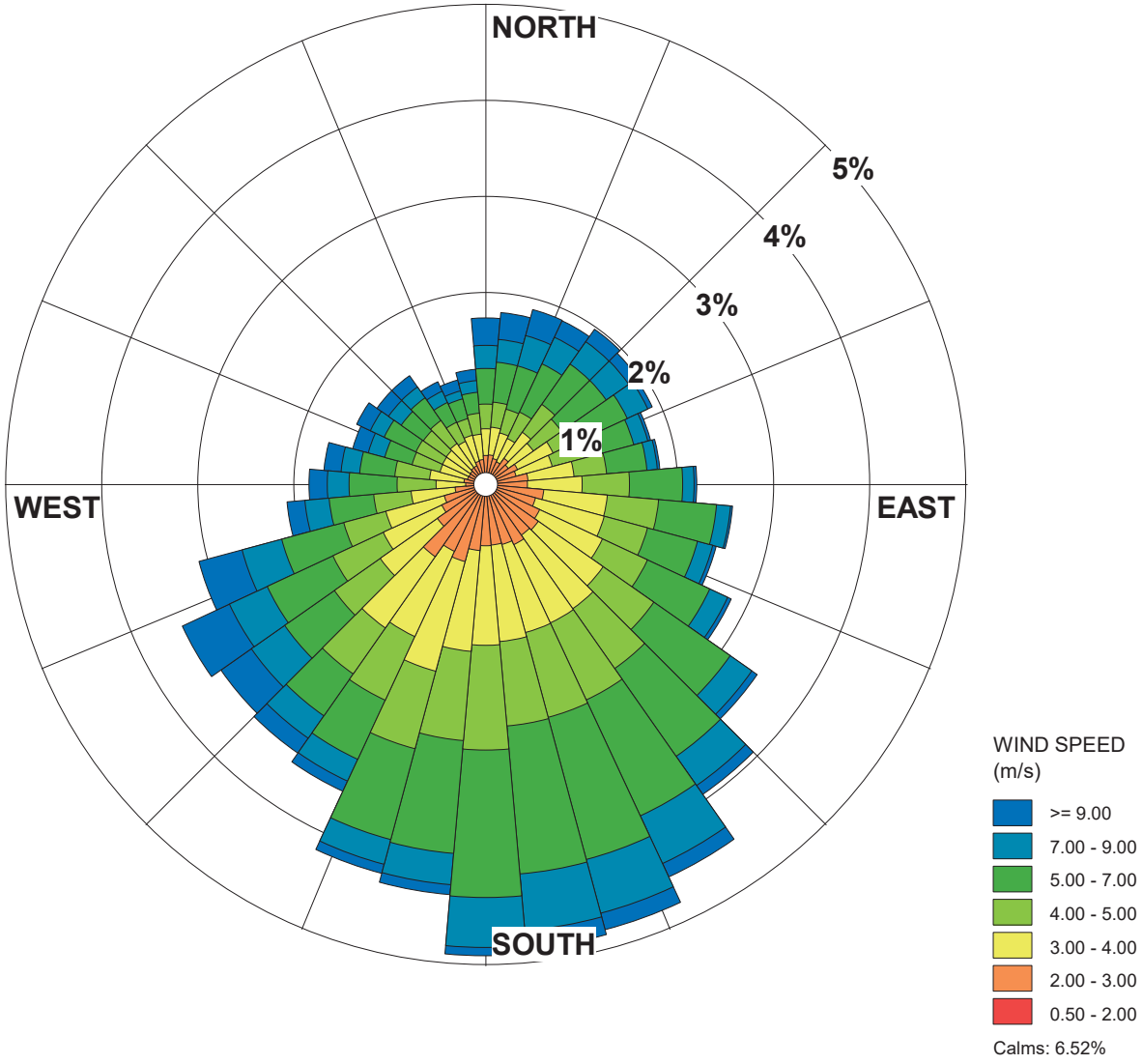


Figure 19.3.2-1
Local Meteorological Stations



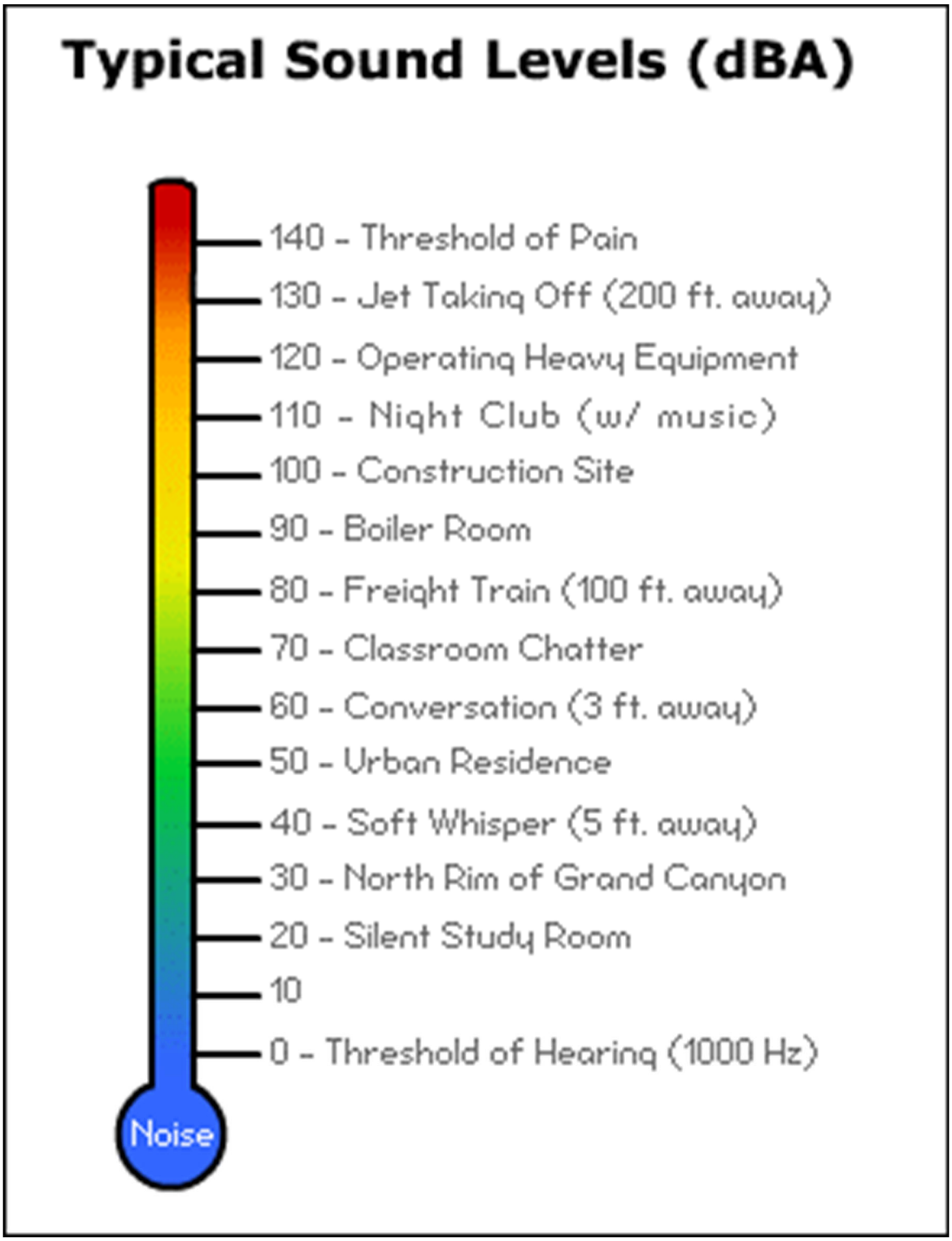
NWS, 2022.

Figure 19.3.2-2
Annual Wind Rose Lea County Regional Airport, New Mexico (2017 – 2021)



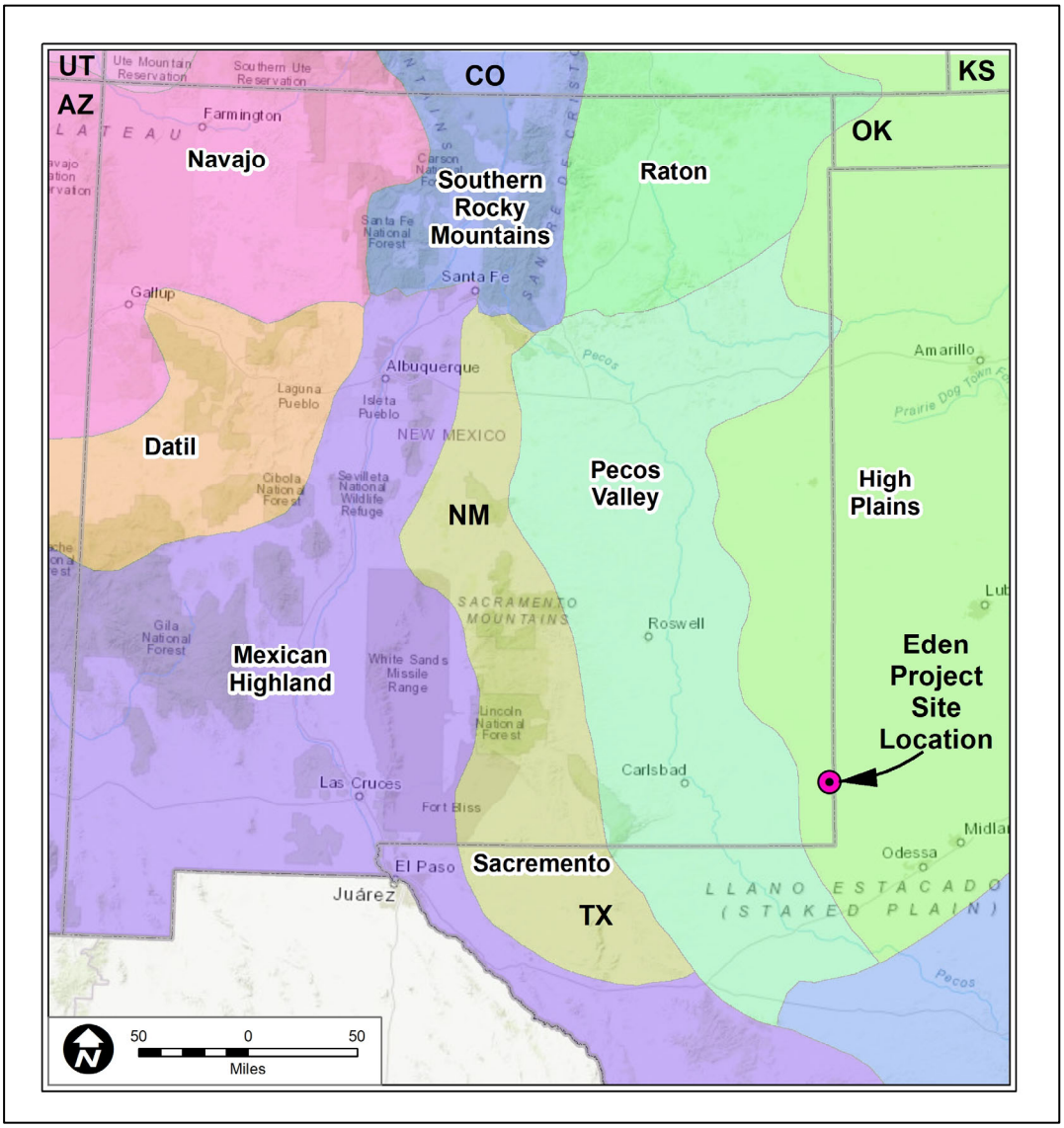
Source: NCEI, 2022f

Figure 19.3.2-3
Typical Indoor and Outdoor Sound Levels



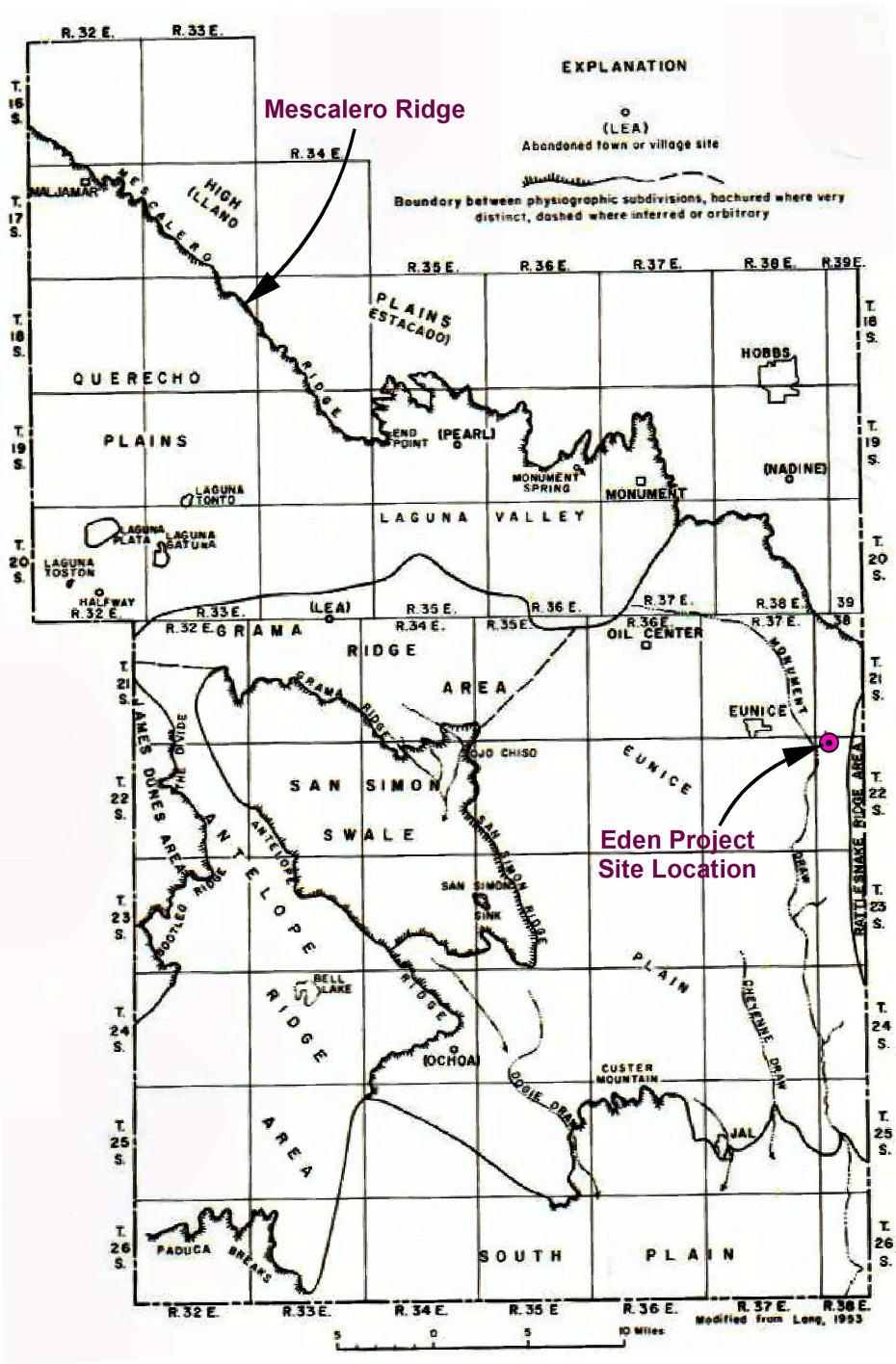
Source: OSHA, 2013.

Figure 19.3.3-1
Regional Physiography



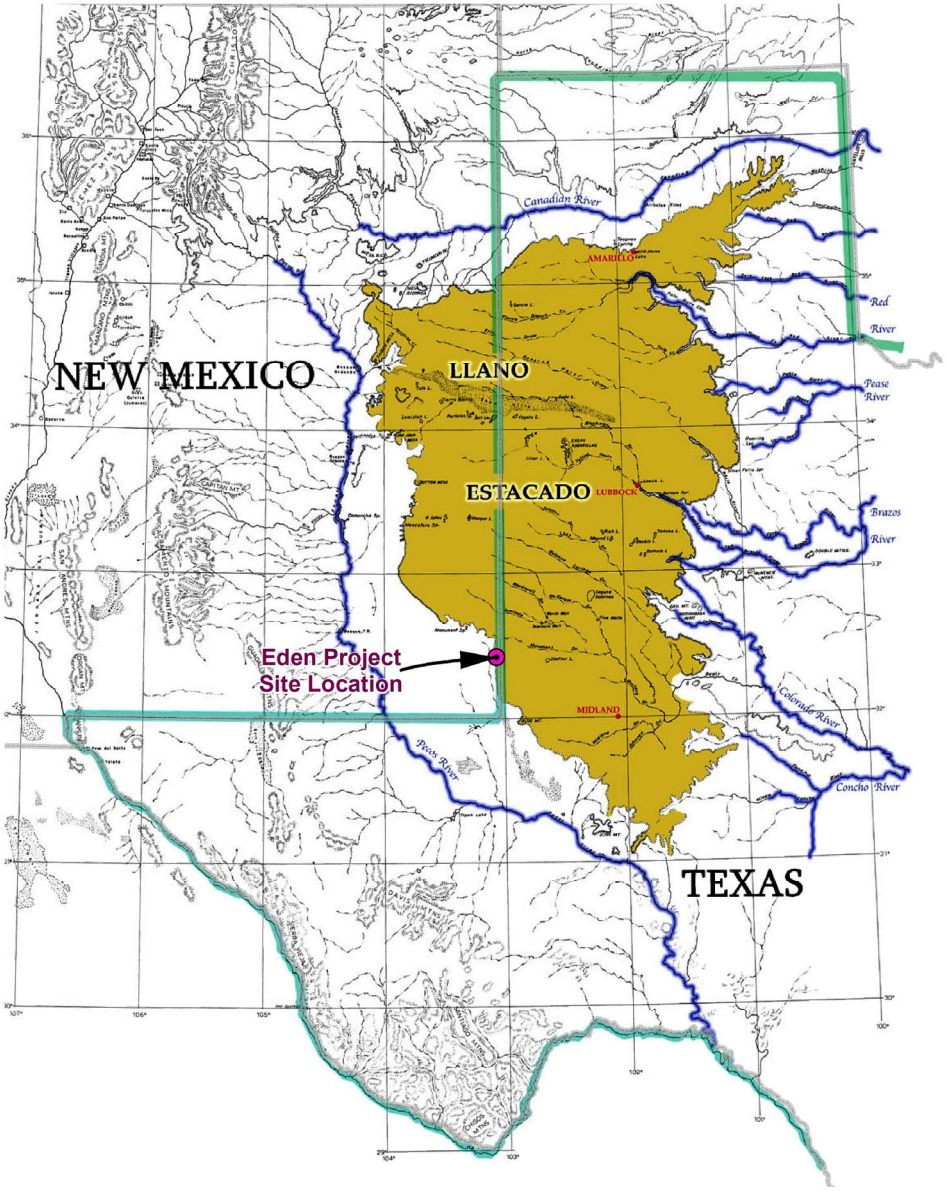
Source: AECOM, 2012.

Figure 19.3.3-2
Physiographic Subdivisions of Southern Lea County, New Mexico



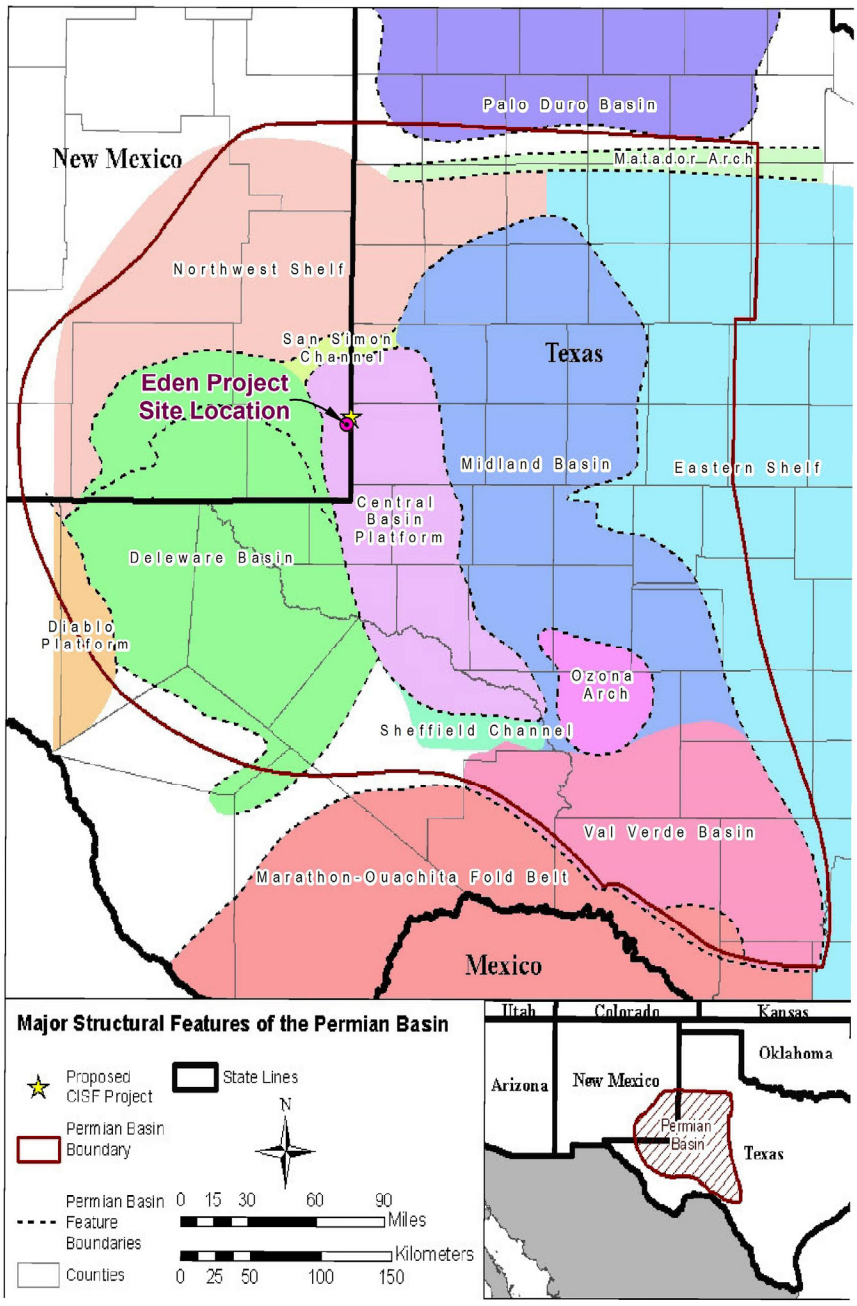
Source: Nicholson and Clebsch, 1961.

Figure 19.3.3-3
Llano Estacado and Vicinity



Source: IIFP, 2009.

Figure 19.3.3-4
Major Structural Features of the Permian Basin of West Texas and Southeastern New Mexico



Source: NUREG-2239

Figure 19.3.3-5
Representative Stratigraphy in Vicinity of the Project Site

ERA	PERIOD	FORMATION	THICKNESS	USCS	LITHOLOGY
CENOZOIC	QUATERNARY	COVER SANDS	1'-10'	SP	SAND, FINE GRAINED, WELL SORTED, UNCONSOLIDATED, LOOSE, ORANGE TO TAN, DRY
		CALICHE	4'-28'	NA	CALICHE WITH SAND MATRIX, CONSOLIDATED, FIRM TO MODERATELY HARD, WHITE TO TAN, DRY
		BLACKWATER DRAW	14'-38'	SP/SC/SM	SAND, W/ SILT AND CLAY, FINE GRAINED, WELL SORTED, UNCONSOLIDATED, ORANGE TO TAN, DRY
	TERTIARY	CALICHE	19'-28'	NA	CALCAREOUS SAND, CONSOLIDATED-VERY HARD, LIGHT GRAY TO WHITE, DRY
		OGALLALA	35'-51'	SW/GW	SAND WITH GRAVEL GRADING DOWNWARD TO A GRAVEL WITH SAND, UPPER SAND IS WELL GRADE, UNCONSOLIDATED, TAN, DRY, LOWER GRAVEL WITH SAND MATRIX, POORLY SORTED, WELL TO POORLY CEMENTED, SUBANGULAR TO SUB ROUNDED, DRY IN THE SOUTHERN PORTION OF CISF SITE, 1-5 FEET OF GROUNDWATER PRESENT IN THE NORTHERN PORTION OF THE CISF SITE
MESOZOIC	CRETACEOUS	ERODED OR NOT DEPOSITED			
	JURASSIC				
	TRIASSIC	DOCKUM/ COOPER CANYON	~1400'/~500'	CL-CH	CLAY, CLAYSTONE, PLASTIC, STIFF, CONSOLIDATED MAROON TO RED, DRY

Source: NUREG-2239.

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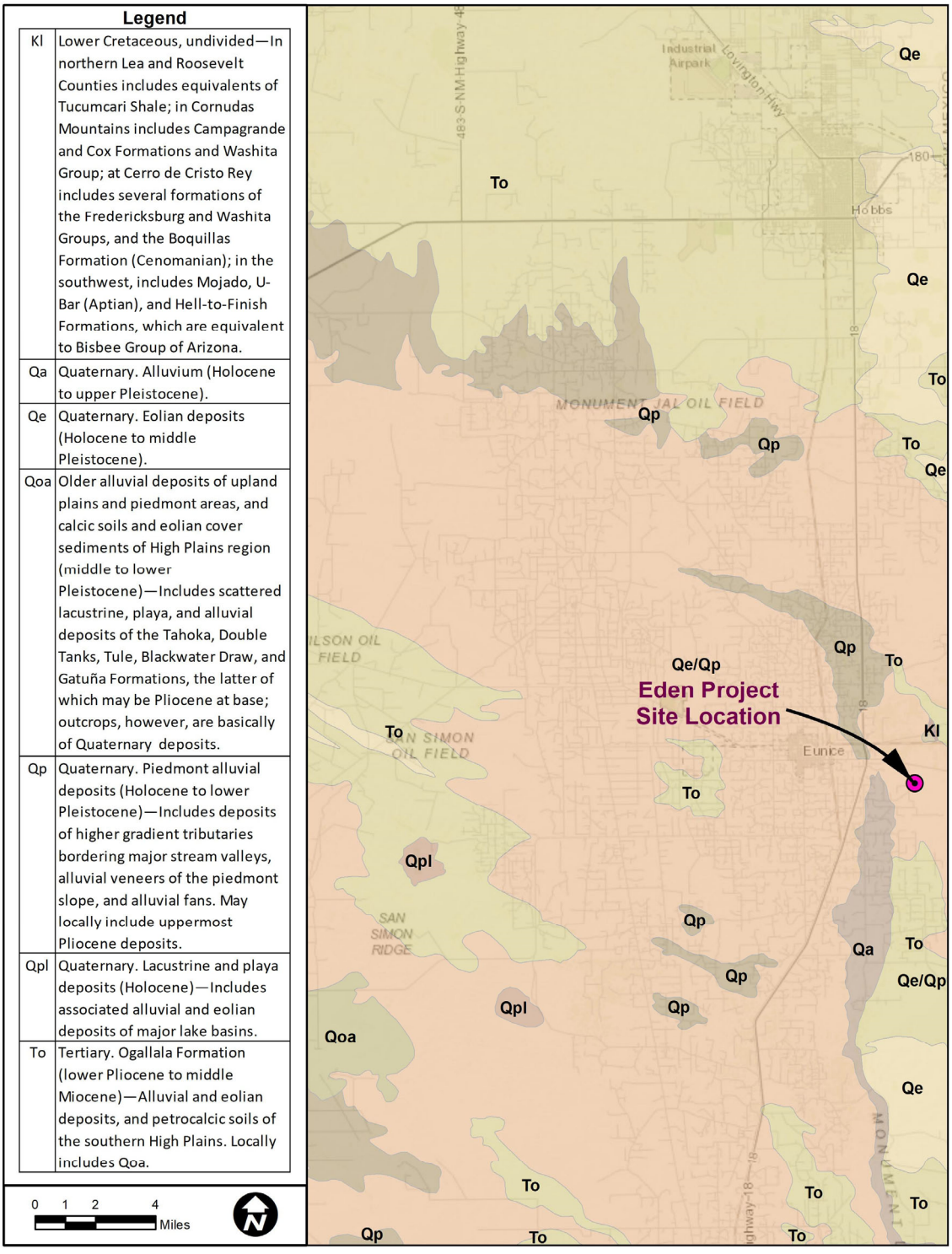
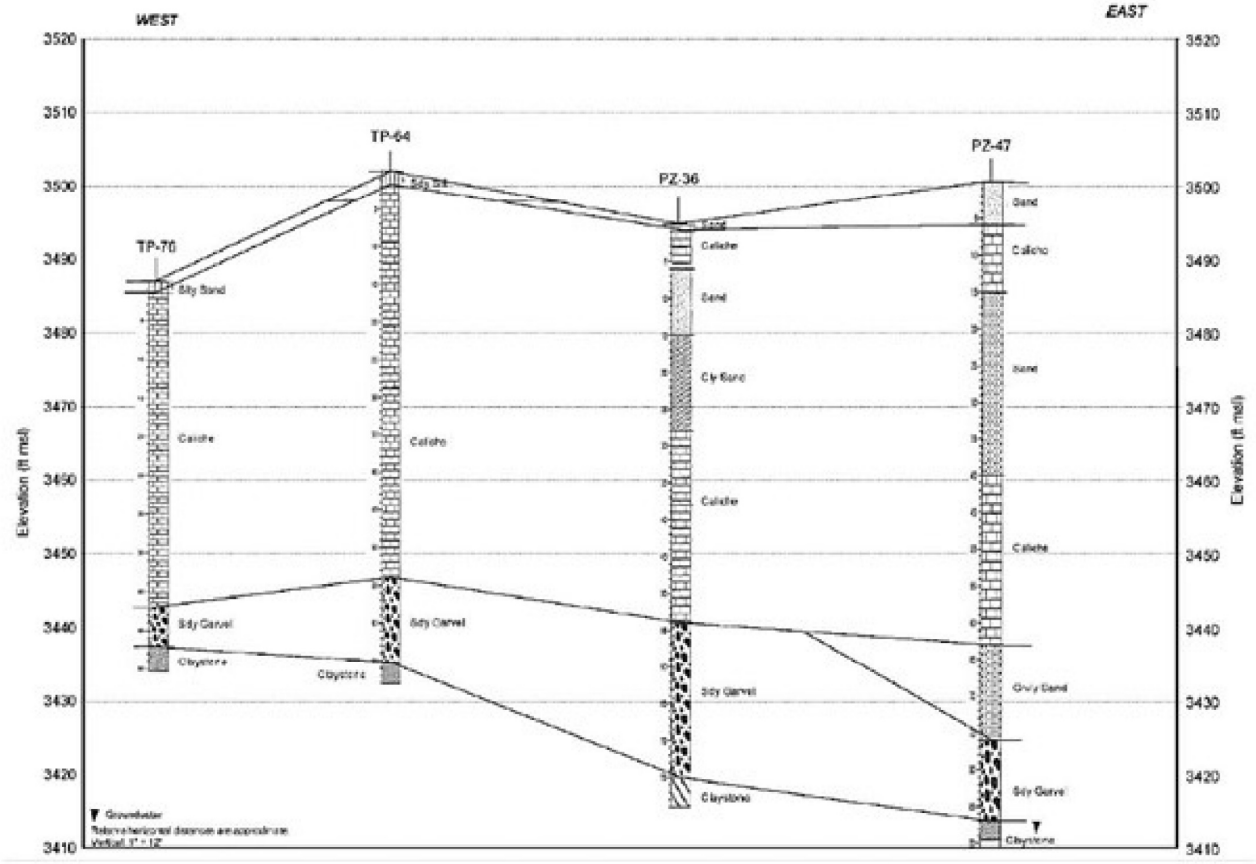
Figure 19.3.3-6
New Mexico Geologic Map of the Project Region



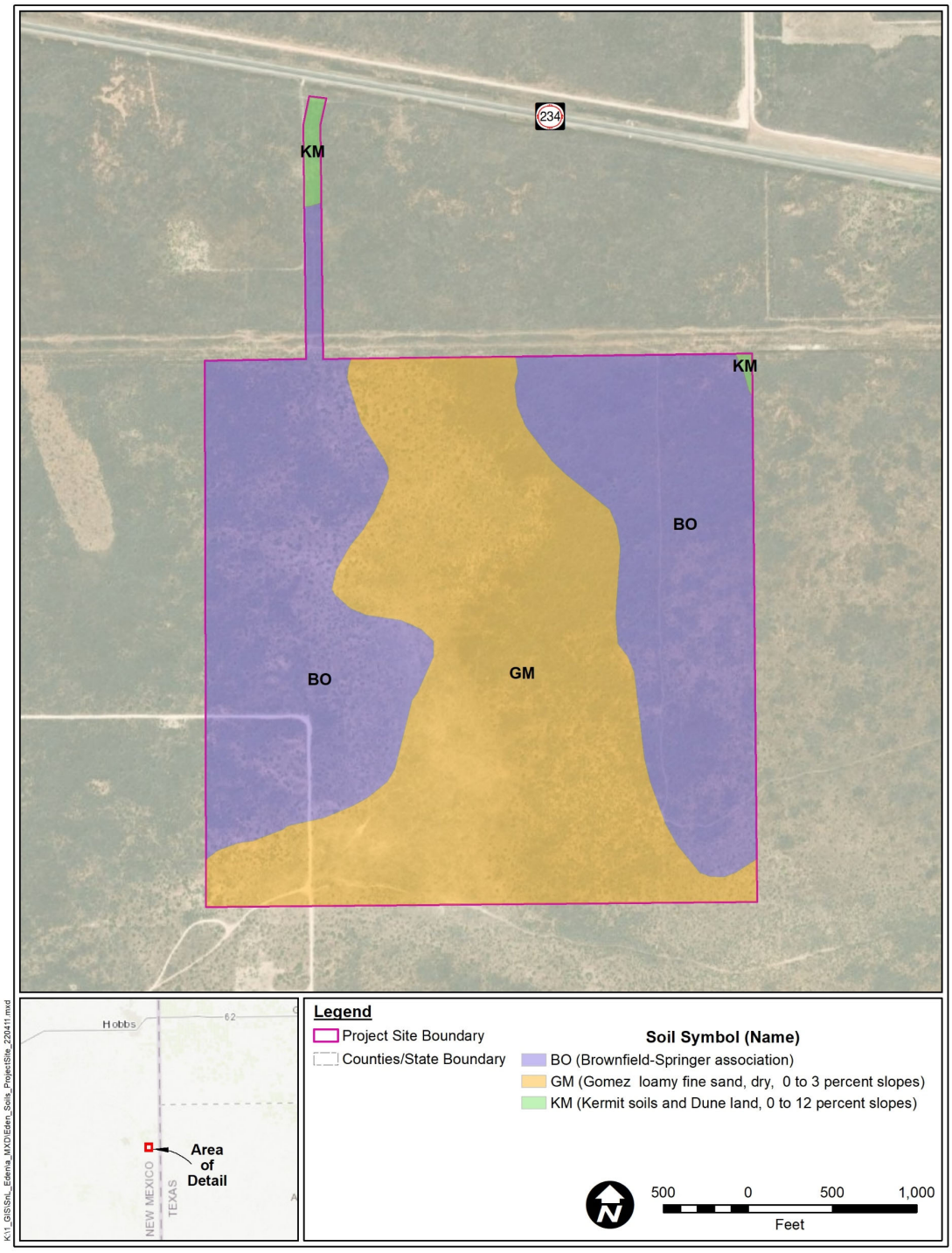
Source: New Mexico Bureau of Geology and Mineral Resources, 2003.

Figure 19.3.3-7
West-East Geologic Cross Section at Consolidated Interim Storage Facility



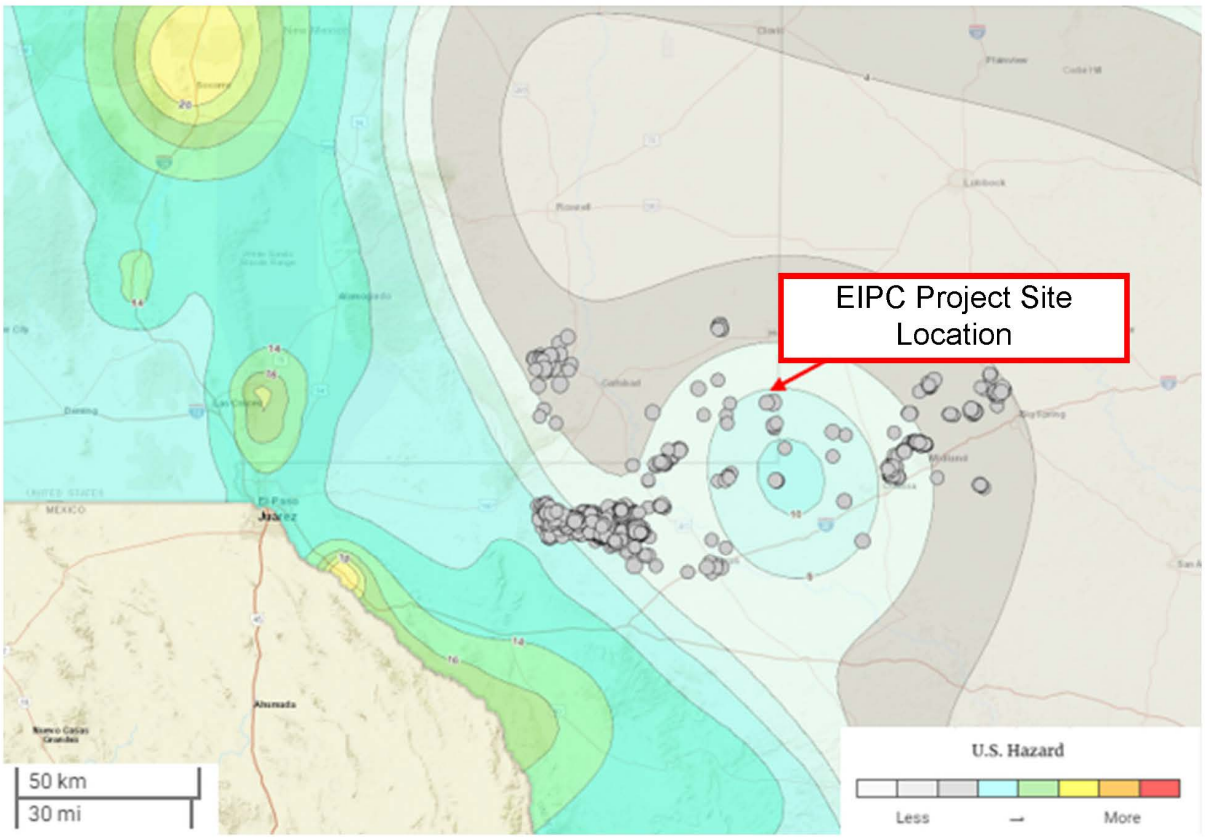
Source: NUREG-2239.

Figure 19.3.3-8
Mapped Soils of the EIPC Project Site



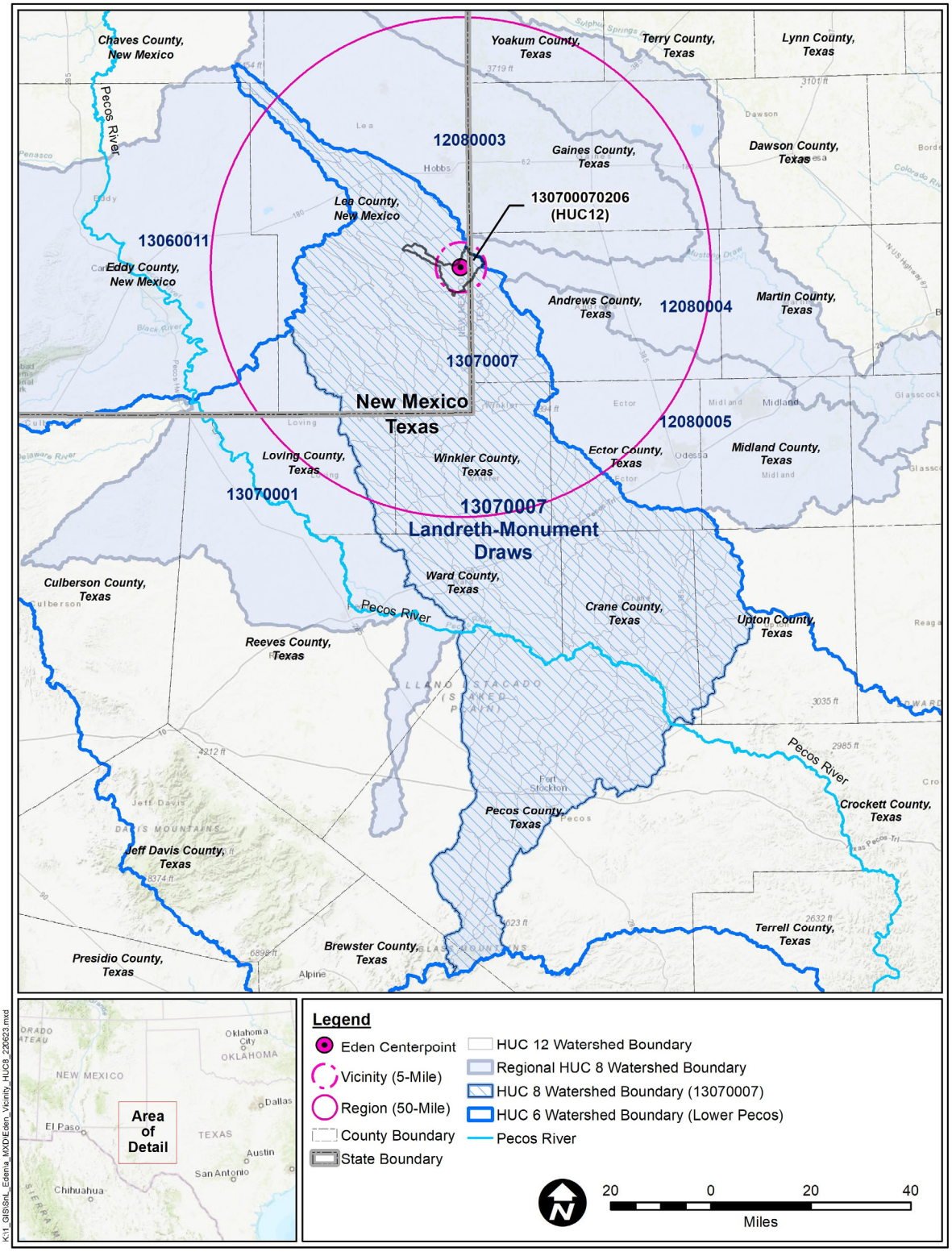
Source: USDA, 2022e.

Figure 19.3.3-9
Recorded Seismic Events from 1950 to 2022 in the Region



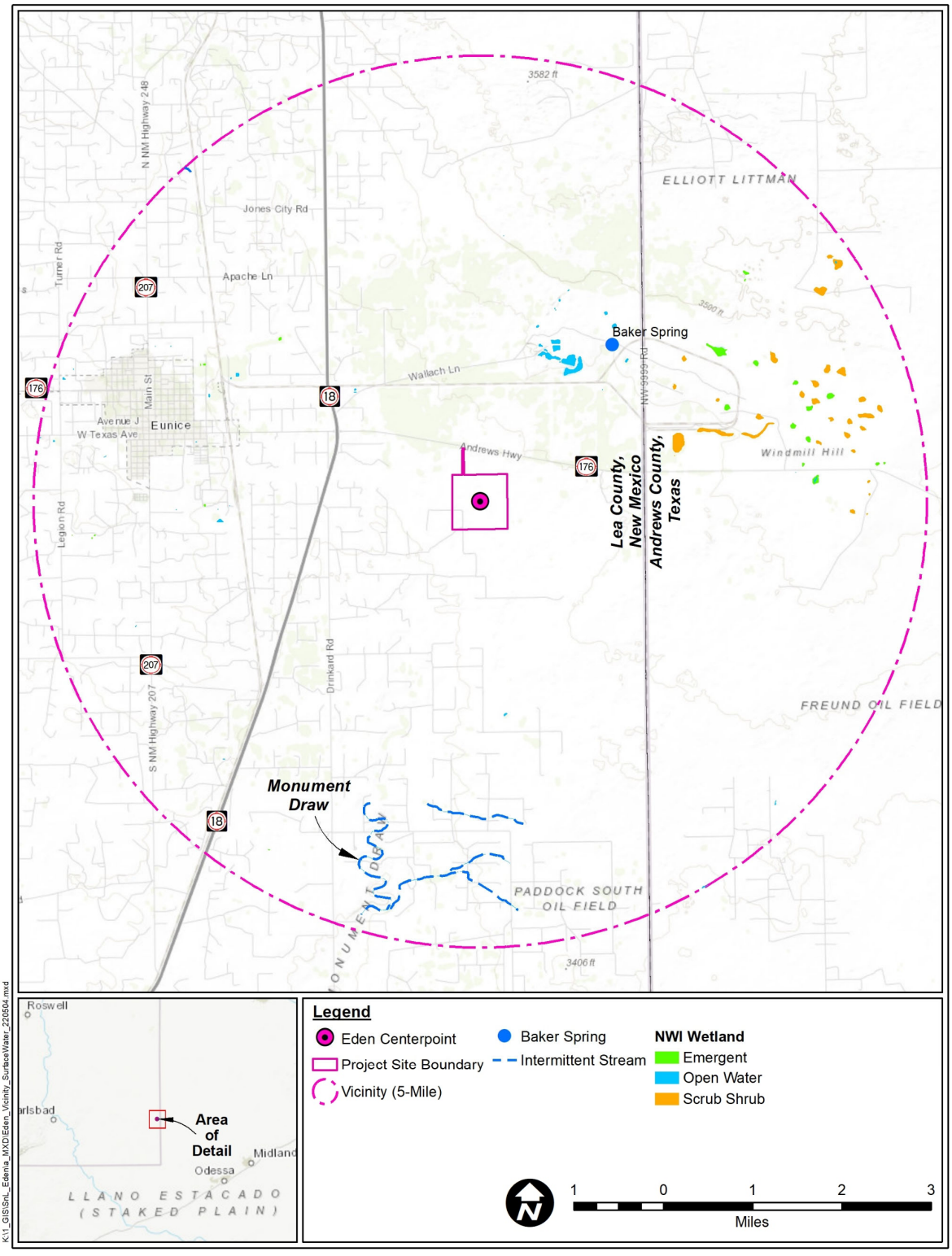
Source: USGS, 2022b.

Figure 19.3.4-1
Landreth-Monument Draw Watershed Extent



Source: USGS, 2022g.

Figure 19.3.4-2
Surface Water Features in the Vicinity of the Project Site



Source: USGS, 2016.

Figure 19.3.4-3
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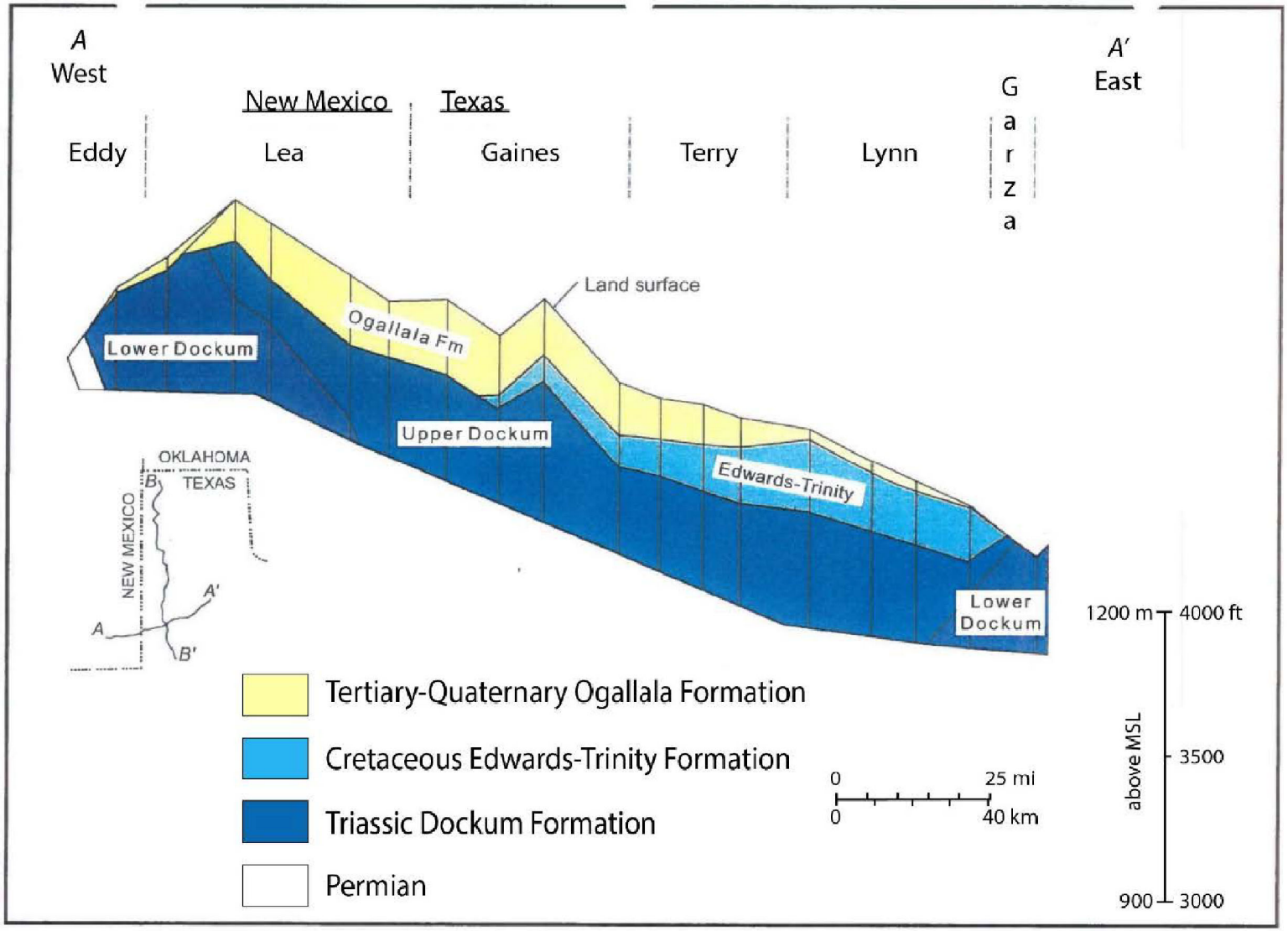

Source: NUREG-2239.

Figure 19.3.4-4
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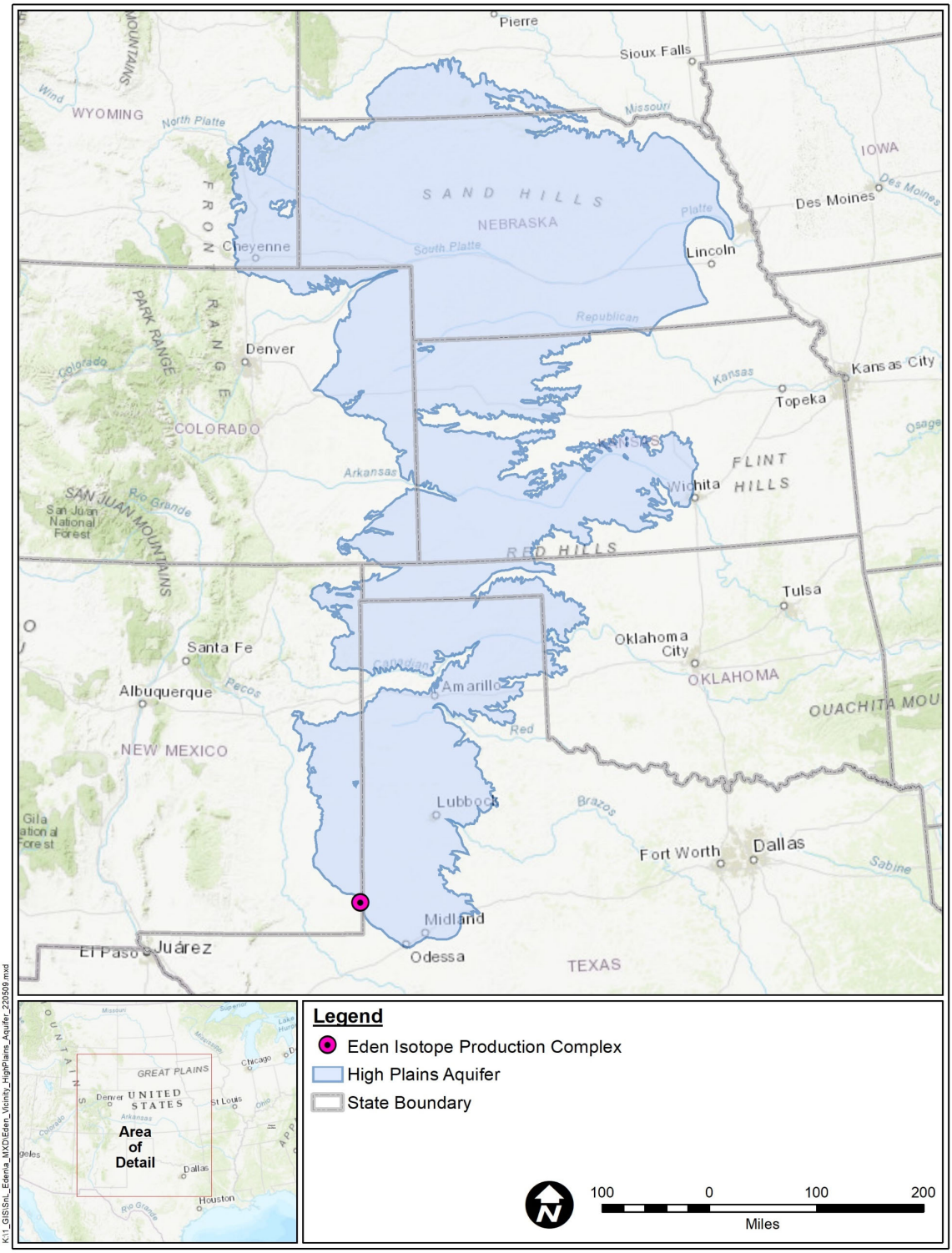

Source: USGS, 2016.

Figure 19.3.4-5
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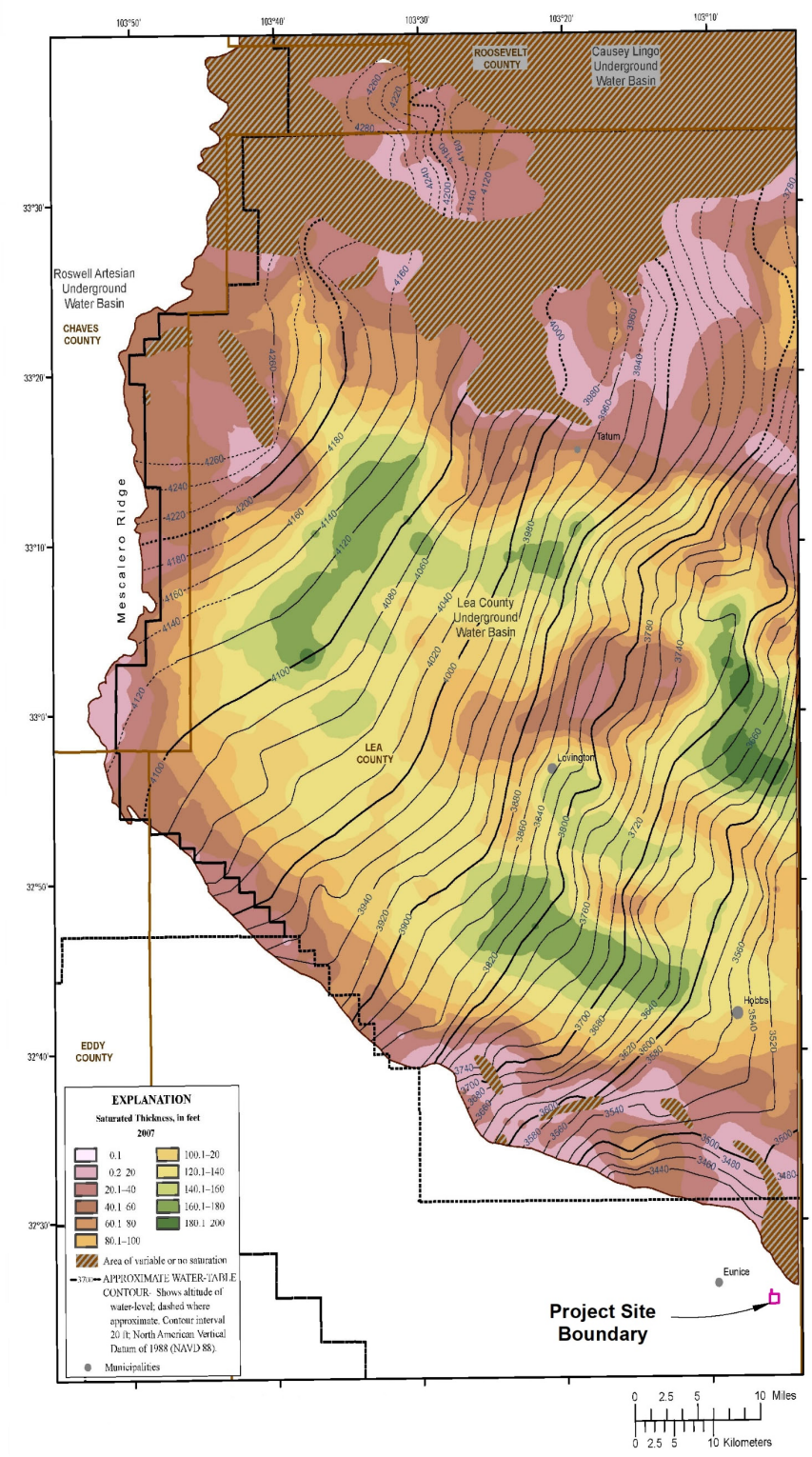

Source: USGS, 2008.

Figure 19.3.4-6
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[[

]]2.390

Source: USGS, 2016.

Figure 19.3.4-7
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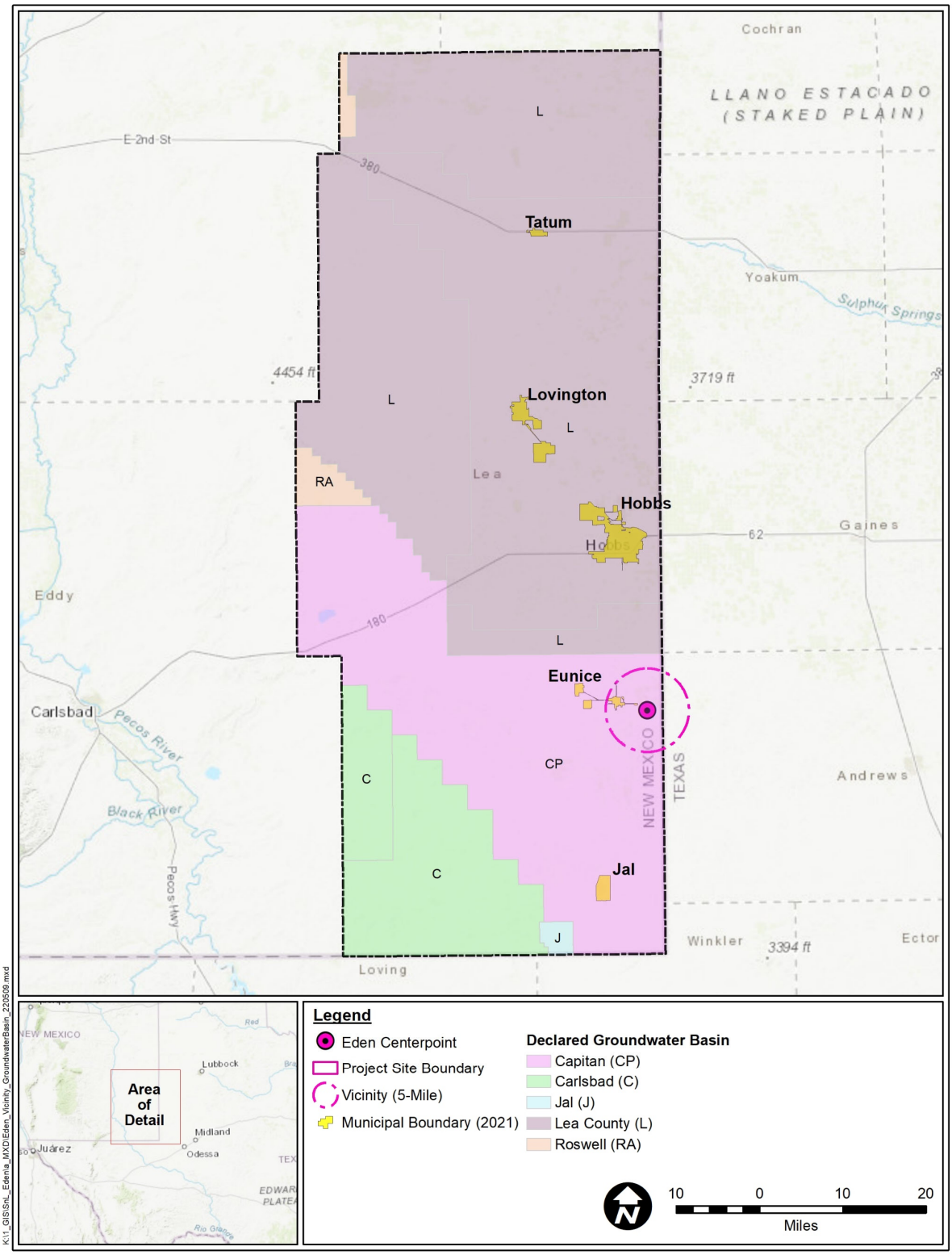

Source: NMOSE, 2020.

Figure 19.3.5-1
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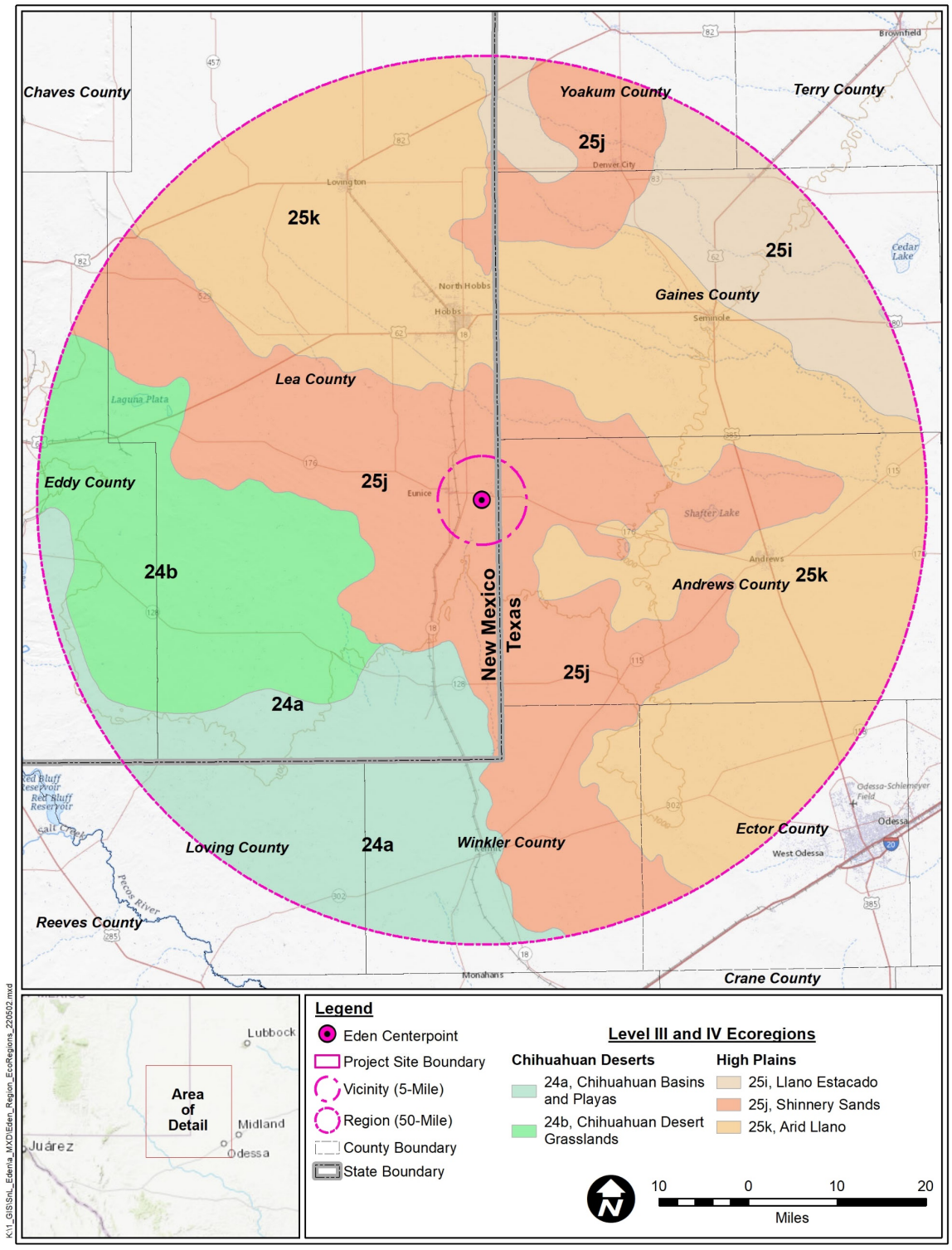

Source: USEPA, 2022e.

Figure 19.3.5-2
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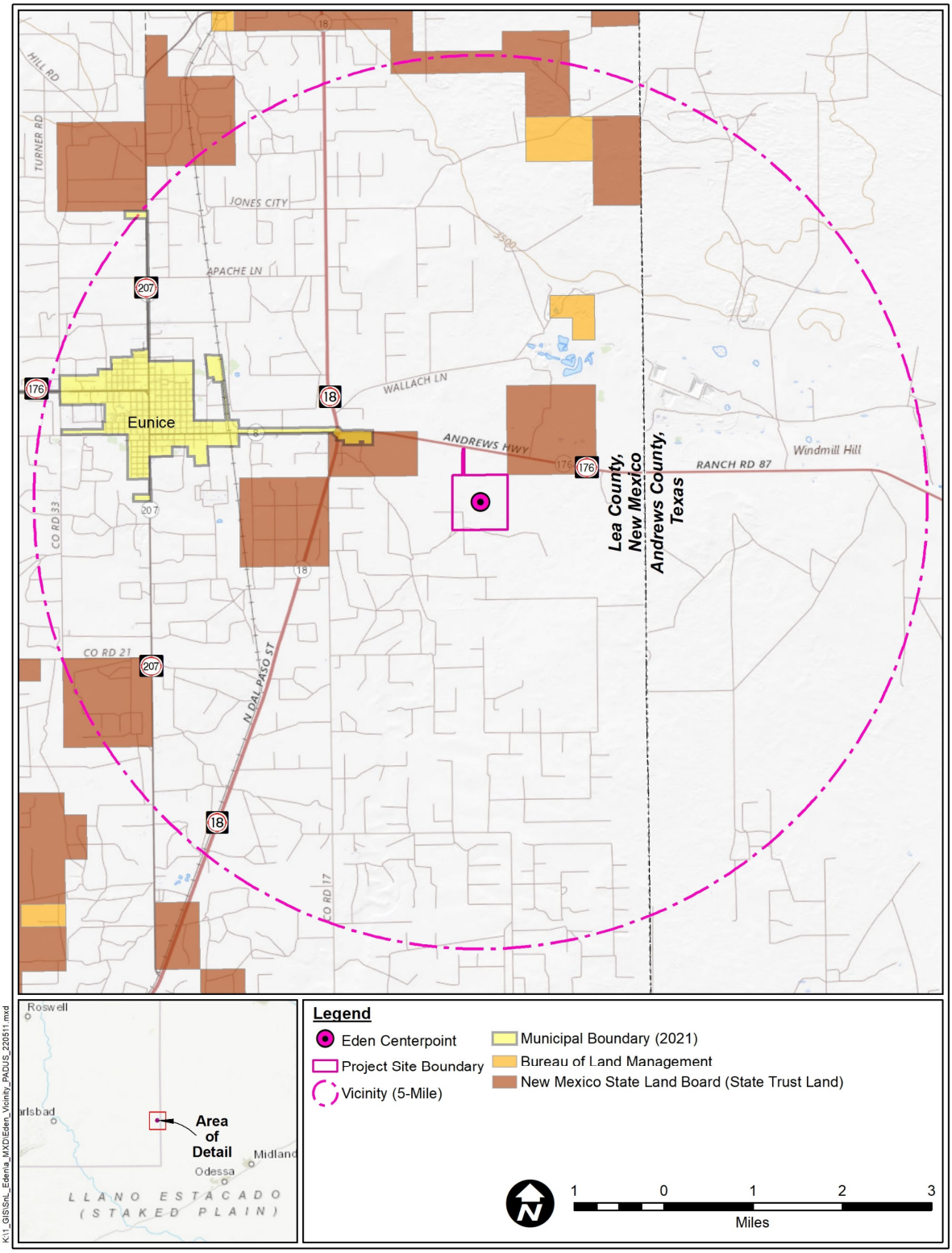

Source: USGS GAP, 2020.

Figure 19.3.7-1
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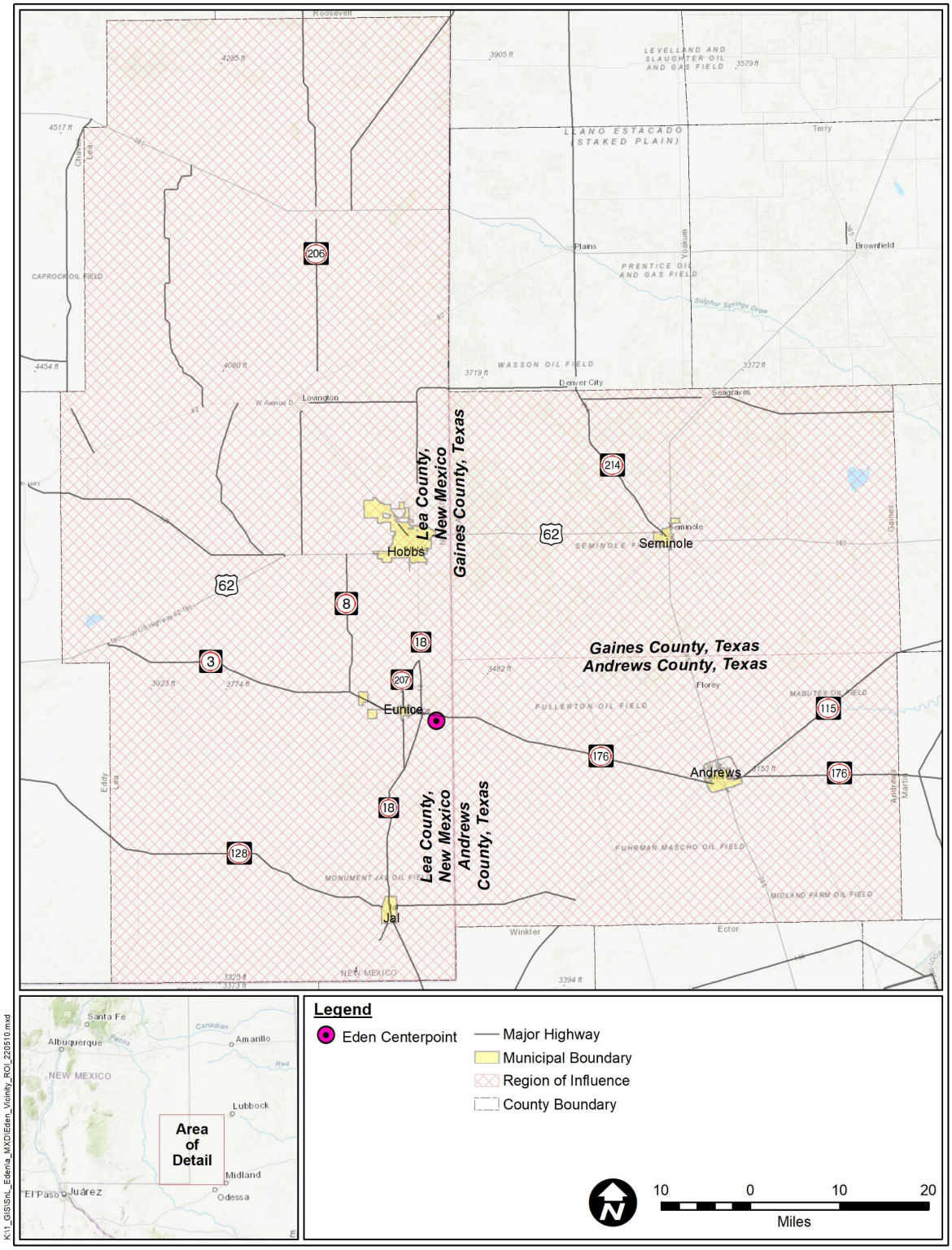

Figure 19.3.7-2
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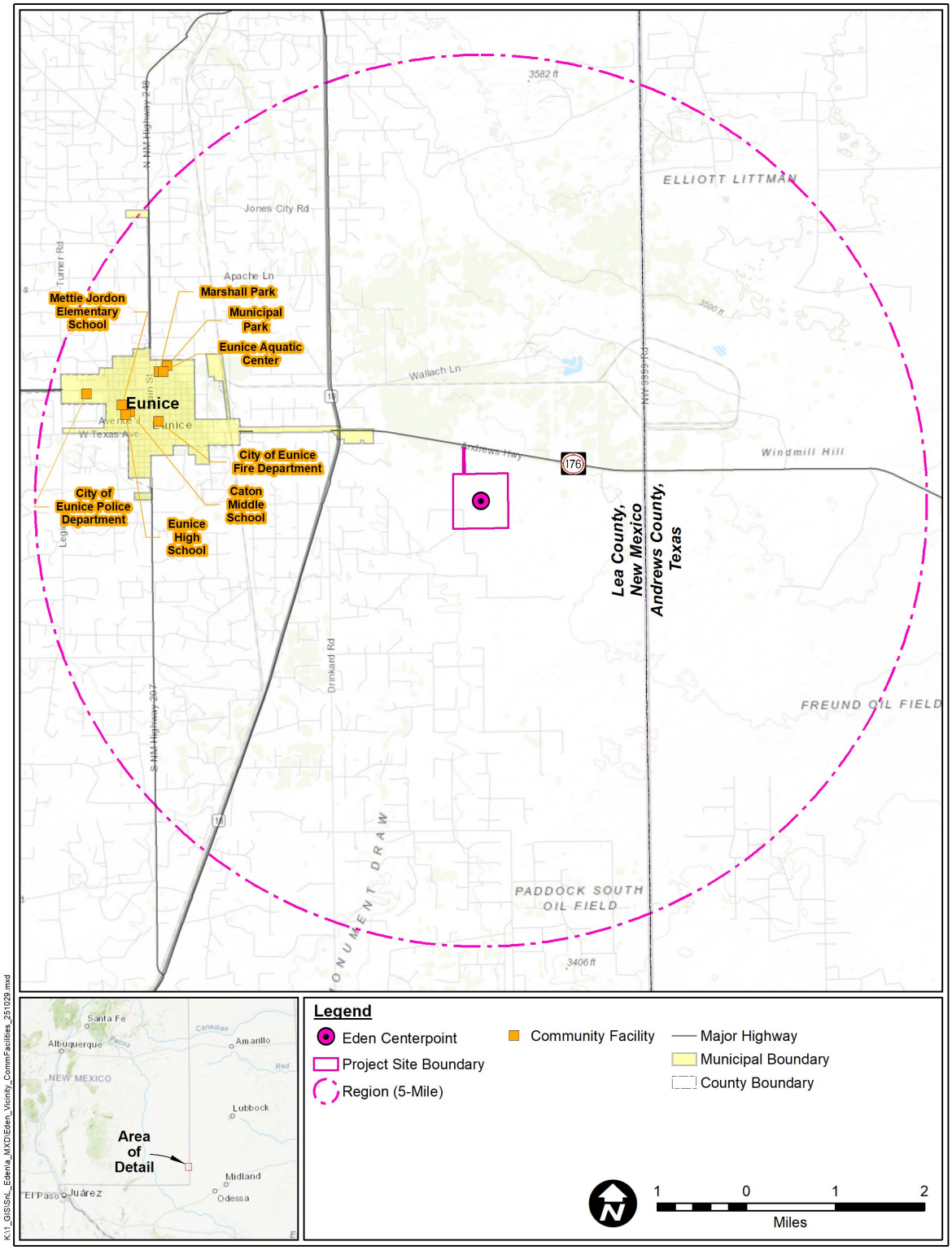

Figure 19.3.8-1
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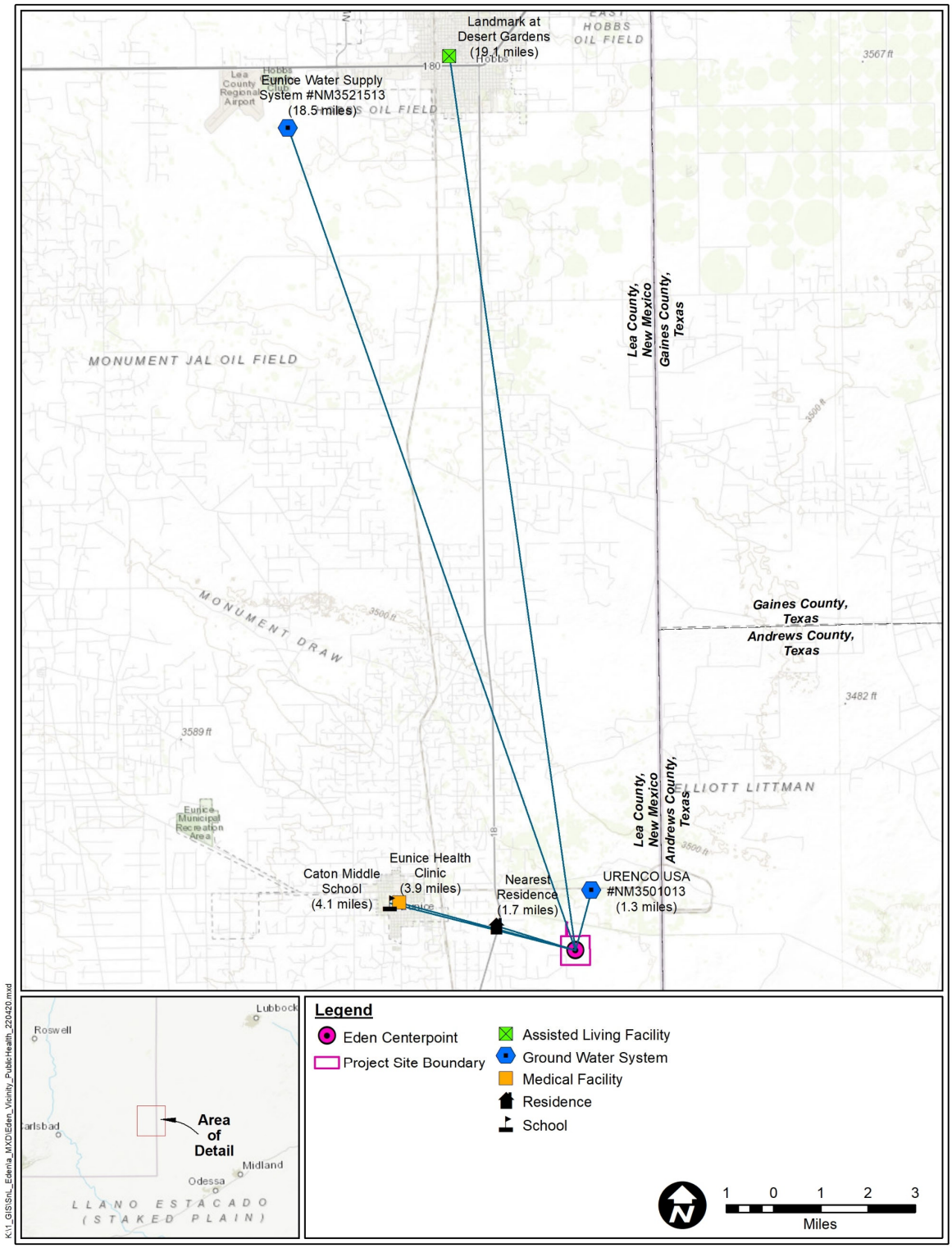

Eden Isotope Production Complex
Preliminary Safety Analysis Report

April 2026
Revision 0

Chapter 19
Environmental Report

Section 19.4
Impacts of Proposed Construction, Operations, and Decommissioning

eden | Precision Science. Human Impact.

CHAPTER 19

ENVIRONMENTAL REPORT

SECTION 19.4 IMPACTS OF PROPOSED CONSTRUCTION, OPERATIONS, AND DECOMMISSIONING

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
°F	degrees Fahrenheit
µg	microgram(s)
µm	micrometer(s)
ac.	acre(s)
ac-ft	acre-feet
acfm	actual cubic feet per minute
AERMOD	American Meteorological Society/USEPA Regulatory Model
AISC	American Institute of Steel Construction
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
APE	area of potential effect
AQB	Air Quality Bureau
Ar-41	argon-41
ASCE/SEI	American Society of Civil Engineers/Structural Engineering Institute
BLM	U.S. Bureau of Land Management
BLS	U.S. Bureau of Labor Statistics
BMP	best management practice(s)
BOP	balance-of-plant
BWXT	BWX Technologies, Inc.
CAA	Clean Air Act
CAM	continuous-air monitor

Acronym/Abbreviation	Definition
CFR	Code of Federal Regulations
Ci	curie(s)
CISF	Consolidated Interim Storage Facility
C.K. Disposal Facility	C.K. Disposal E&P Landfill and Processing Facility
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CT	computed tomography
CWA	Clean Water Act
dBA	A-weighted decibel(s)
DOE	U.S. Department of Energy
D/Q	deposition factor
Eden	Eden Radioisotopes, L.L.C.
EIPC	Eden Isotope Production Complex
EMIF	Eden Medical Isotope Facility
FGDS	Fission Gas Delay System
ft.	foot/feet
FTE	full-time equivalent
FWP	diesel-driven fire water pump engine
GAI	geographic area of impact
gal.	gallon(s)
GHG	greenhouse gas
H-3	tritium
ha	hectare(s)
ha-m	hectare-meter(s)

Acronym/Abbreviation	Definition
HCF	Hot Cell Facility
HEPA	high-efficiency particulate air (filter)
hr.	hour(s)
HVAC	heating, ventilation, and air conditioning
I-131	iodine-131
IE	initiating event
IEEE	Institute of Electrical and Electronic Engineers
IIFP	International Isotopes Fluorine Products Inc.
ISG	Interim Staff Guidance
ISP	Interim Storage Partners
kg	kilogram(s)
Kr-88	krypton-88
kWt	kilowatt-thermal
km	kilometer(s)
L	liter(s)
Lantheus	Lantheus Medical Imaging
lb.	pound(s)
L_{dn}	day-night average noise level
LECS	liquid effluent control system
LEU	low-enriched uranium
LLW	low-level (radioactive) waste
LOS	level of service
Lu-177	lutetium-177
LU/LC	land use/land cover
m	meter(s)

Acronym/Abbreviation	Definition
m^3	cubic meter(s)
MFRS	main force resisting system
mi.	mile(s)
mi^2	square mile(s)
MDCT	mechanical-draft cooling tower
MEI	maximally exposed individual
MGD	million gallons per day
MGPY	million gallons per year
MHA	maximum hypothetical accident
MLD	million liters per day
MLPY	million liters per year
Mo-99	molybdenum-99
mrem	millirem(s)
MRI	Magnetic Resonance Imaging
mSv	millisievert(s)
MW	megawatt(s)
MWt	megawatt-thermal
NAAQS	National Ambient Air Quality Standards
NLCD	National Land Cover Database
NM	New Mexico
NM-18	New Mexico Highway 18
NM-176	New Mexico Highway 176
NMAAQS	New Mexico Ambient Air Quality Standards
NMDGF	New Mexico Department of Game and Fish
NMDOT	New Mexico Department of Transportation

Acronym/Abbreviation	Definition
NMED	New Mexico Environment Department
NMHPD	New Mexico Historic Preservation Division
NMSA	New Mexico Statutes Annotated
NO_X	nitrogen oxides
NO_2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
OSHA	U.S. Occupational Safety and Health Administration
PAC	DOE Protective Action Criteria
PE	postulated event
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter less than 10 µm
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 µm
PMP	probable maximum precipitation
PPE	personal protective equipment
ppm	parts per million
PWH	Production Warehouse
QA	quality assurance
QC	quality control
RADTRAN	Radioactive Material Transport (code)
REMP	Radiological Environmental Monitoring Program
RF	Reactor Facility
ROI	region of influence

Acronym/Abbreviation	Definition
RPS	reactor protection system
sec.	second(s)
SACTI2	Seasonal/Annual Cooling Tower Impact model version 2
SCB	steel confinement box
SDG	standby diesel generator
SO_2	sulfur dioxide
SGCN	Species of Greatest Conservation Need
SHPO	State Historic Preservation Office
SNM	special nuclear material
SOP	sulphate of potash
SPCC	Spill Prevention, Control, and Countermeasure
SRCP	State Register of Cultural Properties
SSC	structure(s), system(s), and component(s)
Sv	Sievert
SWPPP	Stormwater Pollution Prevention Plan
SWReGAP	Southwest Regional Gap Analysis Project
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TPWD	Texas Parks and Wildlife Department
TRAGIS	Transportation Routing Analysis Geographic Information System
TX	Texas
U	uranium
UPSS	uninterruptible power supply system
URENCO	Urenco USA

Acronym/Abbreviation	Definition
UREX	uranium extraction
U.S.	United States
U.S.C.	United States Code
USCB	U.S. Census Bureau
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator
UWB	Underground Water Basin
VOC	volatile organic compound(s)
WCS	Waste Control Specialists
WIPP	Waste Isolation Pilot Plant
Xe-133	xenon-133
Xe-135	xenon-135
yd^3	cubic yard(s)

19 Environmental Report

19.4 IMPACTS OF PROPOSED CONSTRUCTION, OPERATIONS, AND DECOMMISSIONING

This section of the Environmental Report analyzes the impacts of construction, operation, and decommissioning of the Eden Isotope Production Complex (EIPC) site. Overall impact rankings are given to each environmental resource evaluated. Unless otherwise defined, criteria follow the guidance given in United States (U.S.) Nuclear Regulatory Commission (NRC) Impact Rankings in Title 10 of the Code of Federal Regulations (CFR) Part 51 Subpart A, Appendix B, Table B-1, footnote 3, as follows:

- SMALL (S) — Environmental effects are not detectable or are so minor that they neither destabilize nor noticeably alter any important attribute of the resource.
- MODERATE (M) — Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
- LARGE (L) — Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

19.4.1 LAND USE AND VISUAL RESOURCES

This section evaluates the impacts of construction, operations, and decommissioning on land use and visual resources (aesthetic impacts) for the EIPC site and region. As described in Section 19.3.1, land use for the project site and region is analyzed using the U.S. Geological Survey National Land Cover Database (NLCD) land use/land cover (LU/LC) information (Dewitz, 2021). Visual resources are rated using the U.S. Department of the Interior, Bureau of Land Management (BLM) Visual Resource Management program (BLM, 1984). Impacts include effects from activities associated with construction, operation, and decommissioning of the proposed EIPC. These activities include excavation, grading, placement of fill material, temporary staging and construction laydown, construction of permanent features, potential operational disturbances, and dismantlement.

19.4.1.1 Land Use

As described in Subsection 19.3.1.1, the proposed EIPC is located within a 245.6-acre (ac.) (99.4-hectare [ha]) (including easement) project area of land in Lea County, New Mexico (NM) (Figure 19.3.1-3). At full operation, the facilities and infrastructure are located on approximately 55.7 ac. (22.5 ha) within the larger 245.6 ac. (99.4 ha) proposed project area (Figure 19.2.1-4). Land is converted from its current use as undeveloped scrub/shrub to industrial use for the proposed EIPC during the licensing term. Primary land use impacts include land disturbance from construction and operations and reduced usage for agricultural purposes.

19.4.1.1.1 Site and Region

As described in Section 19.3.1, the EIPC consists of a 245.6 ac. (99.4 ha) project area that has historically been used for cattle grazing. The region surrounding the EIPC is defined in Subsection 19.3.1.1.2 as the area within a 5-mile (mi.) (8-kilometer [km]) radius of the site center point. The region includes portions of both Lea County, NM, and Andrews County, Texas (TX).

The potential construction-related land use impacts from the EIPC are based on the EIPC construction plans (see Section 19.2). Activities such as earthmoving, excavation, construction of buildings, concrete equipment, and construction-related traffic generate potential disturbances to land use during the construction phase. Direct construction-related impacts are limited to land within the 245.6 ac. (99.4 ha) project area.

Of the 245.6 ac. (99.4 ha) comprising the EIPC project area, construction permanently converts 55.7 ac. (22.5 ha) of developed low-intensity land use and scrub/shrub use to industrial facility use (Table 19.4.1-1). As described in Subsections 19.2.1.2.2 and 19.2.2.4.3, and 19.2.6.1.1, permanent conversions to industrial facilities include the construction of facility buildings, facility access road and parking lot, storm sewers and stormwater collection basins, evaporation pond, and wastewater management systems. Direct construction impacts also include temporary impact of 37.5 ac. (15.2 ha) of scrub/shrub land used for the construction parking area, construction materials staging or laydown area, and utilities installation. Further details of on-site facilities and construction-phase activities are provided in Section 19.2. Temporary impact areas are either returned to scrub/shrub or restored using native vegetative species.

In addition to the EIPC, the off-site utility corridor (Figure 19.3.1-1) is comprised of scrub/shrub and developed land that is temporarily impacted for utility installation. These temporary impact areas are restored using native herbaceous species.

The loss of scrub/shrub land to industrial facilities is minor when compared with the 46,225.6 ac. (18,706.8 ha) of scrub/shrub remaining within the 5-mi. (8-km) radius of the site (see Table 19.4.1-1). Furthermore, lands on-site not utilized for development of industrial facilities and within the off-site utility corridor are returned to scrub/shrub land or restored using native herbaceous species. As such, impacts to land use from construction and operations are SMALL.

19.4.1.1.2 Special Land Uses

As discussed in Subsection 19.3.1.1.2.1, there are no special land use classifications, such as American Indian or military reservations, Bureau of Indian Affairs land, wild and scenic rivers, national parks, national forests, designated coastal zones, federal wildlife refuges, or wilderness areas within the EIPC region. Therefore, no direct or indirect impacts would occur to these special land use classification areas. There are National Public Lands managed by the Carlsbad Field Office of the BLM within the region and there are Natural Resources Conservation Service prime farmland soils of statewide importance within both the site and the region. Permanent and temporary impacts from construction and operation of the facility occur within the project site, which does not contain National Public Lands special land use areas. Therefore, no direct or indirect impacts would occur to National Public Lands special land use classification areas. However, there are temporary impacts to New Mexico State Trust Land within the off-site utility corridor. These impacts are temporary and occur within a corridor previously disturbed from other utility and infrastructure development. The temporary impacted areas are restored using native herbaceous species. Project impacts to prime farmland soils of statewide importance, however, consist of 54.7 ac. (22.1 ha) classified as permanent impact and 37.5 ac. (15.2 ha) as temporary impact (Table 19.4.1-1). Portions of the off-site utility corridor consist of prime farmland soils, which are temporarily disturbed for utility installation. Project impacts to prime farmland soils are minor when compared with the amount of prime farmland soils remaining in the entire 5-mi. (8-km) region. Therefore, impacts to special land use classification areas are SMALL.

19.4.1.1.3 Agricultural Resources and Facilities

The agricultural resources and facilities on-site and within the region of the EIPC are described in Subsection 19.3.1.1.2.2. Prime farmland of statewide importance makes up 98 percent of the 55.7 ac. (22.5 ha) of permanent construction conversion and 100 percent of the 37.5 ac. (15.2 ha) of temporary construction conversion (NRCS, 2022). However, prime farmland of statewide importance occurs in approximately 23 percent (11,678.6 ac. [4726.2 ha]) of the area within the region (NRCS, 2022). Additionally, as described in Subsection 19.3.1.1.1, before being purchased by Eden Radioisotopes, LLC (Eden), the EIPC site was primarily used for cattle grazing.

Table 19.3.1-3 summarizes the major agricultural crops in the region. Converting lands within the project site to industrial use is unlikely to impact the availability of pastureland or agricultural land within the greater Lea County, NM, and Andrews County, TX, region. No other agricultural resources within the EIPC region are located within the project site and, therefore, are not subject to construction and operations-related impacts.

The loss of agricultural lands, including farmland of statewide importance, and the subsequent loss of potential pastureland to industrial facilities, are minor when compared with the amount of prime farmland of statewide importance, pastureland, and potential crop production remaining within the region surrounding the site (see Table 19.4.1-1). Furthermore, lands not utilized for development of industrial facilities are returned to scrub/shrub land or restored using native, low-water consumption vegetation. As such, direct and indirect impacts to agricultural resources and facilities from construction and operations are SMALL.

19.4.1.1.4 Mineral Resources

Subsection 19.3.1.1.2.3 describes important mineral resources within the region, including nonmetallic construction materials (gravel and sand) and oil and gas availability. Lea County, NM, has more than 16,000 active oil and gas wells. However, none of the reported oil and gas wells or mines are located within the project site boundaries. Consequently, there are no direct or indirect impacts to mineral resources. Impacts to mineral resources from construction and operation of the EIPC are SMALL.

19.4.1.1.5 Major Population Centers and Infrastructure

As described in Subsection 19.3.1.1.2.4, the only major population center within the region is the City of Eunice, NM (see Figure 19.3.1-3). There are several major roadways in the region, including New Mexico Highway 176 (NM-176) and New Mexico Highway 18 (NM-18). NM-176 provides direct access to the EIPC site via the proposed access road. Additionally, a set of acceleration and deceleration lanes on NM-176 are required by New Mexico Department of Transportation (NMDOT) to access and egress the new EIPC access road. None of the population centers or other infrastructure in the region are located within the project site. Permanent and temporary impacts from construction and operation of the facility occur on-site, which includes a proposed access road off NM-176. The off-site utility corridor is not anticipated to impact major population centers and infrastructure. Therefore, construction and operations-related direct and indirect impacts on major population centers and infrastructure are SMALL.

19.4.1.1.6 Conformance with Land Use Plans and Zoning

As described in Subsection 19.4.1.1, land use in the EIPC is converted from current use as undeveloped scrub/shrub to industrial use. However, as discussed in Subsection 19.3.1.1.2.5, Lea County does not have zoning regulations in place and as such the parcel would not require rezoning to allow for construction and operation of the EIPC.

19.4.1.1.7 Impacts of Decommissioning

Following the cessation of operations, the facility is to be decommissioned. Decommissioning activities are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Resultant land uses following decommissioning are undetermined but may consist of industrial reuse, pastureland, or open space. As such, direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction and are SMALL.

19.4.1.1.8 Mitigation Measures

Eden utilizes best management practices (BMPs) and best industry measures during construction, operation, and eventual decommissioning of the EIPC. These practices and measures help minimize impacts to land use within the site and in the surrounding region. Eden utilizes the smallest project footprint possible to limit permanent and temporary conversion of land use within the project boundary and employs silt fencing and straw bales as appropriate to protect undisturbed areas within and adjacent to the project site. Once construction is complete, Eden revegetates bare areas, as appropriate, using native plant species. Additionally, Eden employs shift schedules to minimize impacts to adjacent population centers and roadway infrastructure by reducing the number of vehicles on the roadways.

19.4.1.2 Visual Resources

Impacts to visual and scenic resources from construction are associated with machinery used to excavate and construct the facility. Vehicle traffic and fugitive dust occur during the construction phase. The built facilities and buildings may impact visual and scenic resources during the operations phase. Impacts to visual and scenic resources from the decommissioning phase include similar activities and equipment used during the construction phase.

The visual setting of the area affected by construction and operation of the EIPC site is described in Subsection 19.3.1.2. The existing site is composed entirely of undeveloped land used historically for cattle grazing and has no existing architectural features, established structures, or natural or built barriers, screens, or buffers. As such, the EIPC facilities alter the on-site condition and partially obstruct views of the existing landscape. However, the visual setting of the site is generally flat and uniform in landform with low vegetation diversity and a low scenic quality and sensitivity rating (see Subsection 19.3.1.2.4).

The EIPC structures include an Administration Office Complex, Access Control Center, Production Office Complex, Production Warehouse (PWH), and the Eden Medical Isotope Facility (EMIF). The bounding height of the EIPC for visual impact assessment is the EMIF, which is approximately 42 feet (ft.) (12.8 meters [m]) high. There are three ventilation exhaust stacks, immediately adjacent to the to the Reactor Facility (RF) and Hot Cell Facility (HCF), which are approximately 50 ft. (15 m) high. Figure 19.4.1-1 presents a conceptual rendering of the facility and the arrangements on-site. As described in Subsection 19.3.1.2.1, the proposed

EIPC site is located on relatively flat terrain and the structures are observable from nearby roadways and properties. Visibility for a majority of the EIPC facilities occurs by individuals to the northeast and east where other industrial facilities are located, and by motorists traveling west to east along NM-176. It is unlikely that the proposed facility would be visible from the City of Eunice, NM, which is the closest population center. The few dispersed residences along NM-176 and NM-18 may experience temporary visual impacts of fugitive dust from the project site and from equipment during transit to the project site. The off-site utility installation in the corridor along NM-176 may temporarily impact residences along NM-176 and NM-18 from construction equipment, personal vehicles, fugitive dust, and construction materials. However, these impacts are temporary and confined to the utility corridor along NM-176.

Once construction is complete, the EIPC is not likely to disrupt the existing viewshed of these residences, as the site is similar to other industrial operations in the region and oil and gas mining operations are also present in the area. As stated in Subsection 19.3.1.2.4, the proposed site has a scenic quality classification of “C” and a sensitivity rating of “L,” both of which are lowest in their respective scales and indicate low scenic quality and sensitivity. Therefore, the EIPC does not lower the scenic quality or sensitivity level to the public.

The commuting construction workforce, as described in Subsection 19.2.1.5, would be up to 233 workers and would represent an increase of 466 vehicle trips per day. The addition of these workers along the unpaved access road contributes to fugitive dust in the visual landscape. Additionally, any construction lighting used outside of daylight hours creates temporary visual impacts as it contrasts with the darkness of the surrounding landscape. Although the proposed EIPC alters the existing landscape, based on the absence of regional or local high-quality scenic views in the area, and lack of unique or sensitive viewsheds, impacts to visual and scenic resources from the proposed facility are SMALL.

As described in Subsection 19.3.1.2.1, the viewshed to the east consists of pastureland and the Lea County Landfill and to the northeast the Urenco, USA (URENCO) facility. To the south and west, the viewshed is primarily pastureland. Because the viewshed to the northeast and east includes major industrial and commercial facilities, addition of the EIPC facilities does not significantly alter the visual setting. Therefore, impacts to visual resources from construction and operation of the EIPC are SMALL.

As discussed in Subsection 19.4.2.1, plume visibility from the production process is expected to be minimal. The EIPC includes two cooling towers for the secondary coolant system. The EIPC does not utilize radar towers or other large structures that visibly intrude upon the existing landscape. Based on these site characteristics and on the bounded dimensions of the facility, as detailed above and illustrated in Figure 19.4.1-1, facility structures have a relatively low profile and, therefore, any impacts to the viewshed are SMALL.

At the end of the license term, the EIPC is to be decommissioned for unrestricted use and termination of the license. Decommissioning activities are similar to those of the construction phase; therefore, impacts are similar and SMALL.

19.4.1.2.1 Mitigation Measures

Eden utilizes BMPs and best industry measures during construction, operation, and eventual decommissioning of the EIPC. These practices and measures help minimize impacts to visual resources. Eden minimizes visual impacts to residents and motorists by limiting the placement

of equipment, vehicles, and construction materials close to NM-176. Additionally, Eden revegetates bare areas as appropriate, to minimize visual disruption to the surrounding areas.

Table 19.4.1-1
Effects on Land Use/Land Cover and Prime Farmland within the Project Area and Region

	EIPC Project Area (Permanent Disturbance)		EIPC Project Area (Temporary Disturbance)		Region	
NLCD Class	**Acres**	**Percent[(a)]**	**Acres**	**Percent[(a)]**	**Acres**	**Percent[(a)]**
Barren Land					480.8	1.0
Cultivated Crops					22.5	<0.1
Developed, High Intensity					147.0	0.3
Developed, Medium Intensity					743.7	1.5
Developed, Low Intensity	<0.1	0.0			849.2	1.7
Developed, Open Spaces					1559.3	3.1
Herbaceous					145.6	0.3
Open Water					88.5	0.2
Scrub/Shrub	55.7	100	37.5	100	46225.6	92.0
Woody Wetlands					2.7	<0.1
Total	**55.7**		**37.5**		**50264.9**	
Prime Farmland Class						
Not Prime Farmland	1.0	2			38586.3	
Prime Farmland of Statewide Importance	54.7	98	37.5	100	11678.6	
Total	**55.7**		**37.5**		**50,264.9**	

Source: Dewitz, 2021; NRCS, 2022
a) Total may be more or less than 100 percent due to rounding.
Abbreviations: EIPC = Eden Isotope Production Complex | NLCD = National Land Cover Database

19.4.2 AIR QUALITY AND NOISE

This section addresses the direct physical impacts of construction, operations, and decommissioning on the communities within the vicinity of the proposed EIPC project site. Direct physical impacts include the effects from air emissions and noise. This evaluation indicates the magnitude of potential impacts and whether mitigation measures are required.

19.4.2.1 Air Quality

This subsection describes the air quality impacts of construction, operation, and decommissioning of the EIPC. The EIPC is located near Eunice, NM, on the proposed EIPC site. New on-site air emission sources are created at the proposed project site during construction, operation, and decommissioning of the proposed EIPC.

19.4.2.1.1 Air Quality Impacts from Construction

Construction activities result in localized increases in air emissions. Earthmoving, excavation, clearing, pile driving, erection, batch plant operation, and construction-related traffic generate fugitive dust and fine particulate matter that potentially impact both on-site workers and off-site residents of the community. Vehicles and engine-driven equipment (e.g., generators and compressors) generate combustion product emissions such as carbon monoxide (CO), nitrogen oxides (NO_x), and to a lesser extent, sulfur dioxide (SO_2). Painting, coating, and similar operations also generate emissions from the use of volatile organic compounds (VOCs).

In addition to fugitive-dust emissions generated by the movements of heavy, off-road construction equipment at the EIPC project site, other air emissions are released from the exhaust of the diesel engines used to power this equipment. Different mixes of heavy-duty, off-road construction equipment are used for EIPC project site preparation and access-road construction (e.g., dozers, graders, loaders) than are used during the later construction stages involving erection of the buildings, installation of utilities, and other general construction activities (e.g., cranes, forklifts, aerial lifts). Exhaust air emissions from diesel-engine-powered off-road equipment consist of CO, NO_x, SO_2, particulate matter with an aerodynamic diameter less than 10 micrometers (μm) (PM_{10}), and VOCs. The emissions from each type of off-road equipment are a function of equipment-specific factors, including engine horsepower, load factor, and hours of operation.

People living near or working at or near construction sites may be subject to the physical impacts of construction activities. Activities associated with the use of construction equipment may result in varying amounts of dust, air emissions, noise, and vibration. The magnitude and area of extent of the impacts from these emissions depends on atmospheric conditions at the time of the activity. The magnitude of these potential impacts is typically related to the specific construction activities that occur at a given site, the nature and effectiveness of implemented environmental controls, and the proximity of the site to populated areas. Contractors, vendors, and subcontractors are required to adhere to appropriate federal and state occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions.

On-site equipment use and traffic due to construction activities can also result in on-site increases in emissions. While guidance from the Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-

Power Reactors – Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors, suggests that emissions from on-site and off-site vehicle use (including fugitive dust) be estimated, Eden believes that this information is not necessary to evaluate the impacts of the EIPC given the absence of near off-site receptors, the short-term duration of such emissions, and as discussed in Section 19.3, the classification of the regional air quality as “attainment.” Analysis of on-site and off-site vehicle use, including fugitive dust, are more appropriate for projects requiring a Conformity Analysis in non-attainment areas (40 CFR Part 93, Subpart B). Because construction equipment uses and generated traffic volumes are relatively minor compared to other regional traffic generated emissions, and because the EIPC site is largely surrounded by rangeland and other undeveloped areas, potential air quality impacts from construction are expected to be limited. Implementation of controls and limits at the source of emissions on the construction site result in reduction of impacts off-site. For example, the dust control program reduces dust due to construction activities to minimize dust reaching site boundaries. Transportation and other off-site activities result in dust emissions from vehicle usage. Off-site transportation activities generally occur on improved surfaces, limiting fugitive dust emissions. Specific mitigation measures to control fugitive dust may include any or all of the following:

- Stabilizing construction roads and spoil piles.
- Limiting speeds on unpaved construction roads.
- Periodically watering unpaved construction roads.
- Performing housekeeping (e.g., remove dirt spilled onto paved roads).
- Covering haul trucks when loaded or unloaded.
- Minimizing material handling (e.g., drop heights, double-handling).
- Phased grading to minimize the area of disturbed soils.
- Re-vegetating road medians and slopes.

While emissions from construction activities and equipment are unavoidable, implementation of mitigation measures minimize impacts to local ambient air quality and the nuisance impacts to the public in proximity to the project. The mitigation of engine emissions may include any or all of the following:

- Implementing controls to minimize daily emissions such as reducing engine idle time, using cleaner fuels (e.g., ultra-low sulfur diesel fuel or biodiesel), installing pollution control equipment on construction equipment (e.g., diesel oxidation catalysts and particulate matter filters), and curtailing or controlling the time of day construction activities are performed.
- Performing proper maintenance of construction vehicles to maximize efficiency and minimize emissions.

In summary, air emission impacts from construction are SMALL because emissions are controlled at the source where practicable; are regularly maintained within established regulatory limits designed to minimize impacts; and are located a significant distance from the public. Moreover, if air permits are ultimately deemed required for associated endeavors, they would be obtained as appropriate.

19.4.2.1.2 Air Quality Impacts from Operations

The design of the EIPC includes three (3) standby diesel generators, one (1) diesel driven fire water pump engine (FWP), and two (2) cooling towers. Details on these sources are discussed in Section 19.2. The potential impacts from these sources are detailed in the following subsections.

As discussed in Subsection 19.3.2.1.6, the U.S. Environmental Protection Agency (USEPA) uses criteria pollutants as indicators of air quality. Concentrations above the allowable maximum, as defined by the National Ambient Air Quality Standards (NAAQS), may cause adverse effects on human health. Table 19.3.2-15 and Table 19.3.2-16 present a list of the NAAQS and the State of New Mexico Ambient Air Quality Standards (NMAAQS). Existing air quality is discussed in Section 19.3.

19.4.2.1.2.1 Gaseous Effluents

Gaseous effluent sources during operations at the EIPC are:

- Radionuclides in gaseous form escaping from the RF pool.
- Radionuclides in gaseous form escaping from the evaporation pond.
- Radionuclides in gaseous form generated in the separation processing.
- Particulate matter from the cooling towers.
- Combustion gases from FWP.
- Combustion gases from standby diesel generator(s).

19.4.2.1.2.1.1 Radionuclide Emissions

Discussion on radionuclide emissions can be found in Subsection 19.4.8.2.

19.4.2.1.2.1.2 Fuel Combustion Emissions

Several combustion sources at the EIPC contribute to the gaseous effluents. These combustion sources are three standby diesel generators, and a FWP.

Operation of the standby diesel generators and FWP would result in a slight increase in emissions; however, emissions would be low due to their intermittent use. Each of these sources vents emissions to the outside through an associated stack. Table 19.4.2-1 and Table 19.4.2-2 summarize the NO_x, CO, VOCs, particulate matter (PM), PM_{10}, particulate matter with an aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), SO_2, and carbon dioxide (CO_2) emissions. Total annual emissions are presented in Table 19.4.2-3.

Due to the nature of their intermittent use, gaseous effluent control systems are not included in the design for these sources.

19.4.2.1.2.1.3 Cooling Towers

There are two cooling towers (one operational, one spare) at the EIPC that contribute to PM emissions. The cooling towers provide heat rejection for the reactor primary coolant system. Table 19.4.2-4 summarizes the PM, PM_{10}, and $PM_{2.5}$. Total annual emissions are presented in Table 19.4.2-3.

19.4.2.1.2.2 Evaluation of Emission Impacts on Air Quality

19.4.2.1.2.2.1 Vehicle and Other Emissions

During the operations phase, vehicular air emissions occur from the commuting workforce and from routine deliveries to/from the EIPC. As described in Section 19.4.7, the volume of traffic generated during operations is considerably lower than that expected during construction. Additionally, the lands on the developed EIPC site are either developed surfaces (buildings, paved parking/access road) or of a landscaped variety.

Limitation of routine vehicle uses to paved areas reduces the emissions of fugitive dust. Impacts from vehicular air emissions and fugitive dust during operations are far less than impacts from these sources (as well as from heavy equipment and generator use) during the construction phase.

Impacts during the operations phase are, therefore, SMALL.

19.4.2.1.2.2.2 Release Point Characteristics

Emissions and stack characteristics for each emission source are based on design parameters, assumptions, information from vendors, and emission factors. The characteristics are listed in Table 19.4.2-5 and Table 19.4.2-6.

19.4.2.1.2.2.3 Cooling Tower Impact Modeling Assumptions and Results

A cooling tower impact study was prepared for EIPC. The study uses the Electric Power Research Institute's Seasonal/Annual Cooling Tower Impact model Version 2 (SACTI2). SACTI2 predicts mineral deposition, ground fogging, plume rime icing, and plume shadowing from mechanical-draft cooling towers (MDCTs). The model results are summarized below.

19.4.2.1.2.2.3.1 Model Results

The maximum modeled impacts are summarized in Table 19.4.2-7, the highest modeled impacts are listed below.

All of the maximum modeled impacts are contained within the owner-controlled area of the EIPC. Due to the limited temporal and spatial impacts of the plume, fogging, icing and visibility impacts of the MDCTs are not a significant concern.

The modeled mineral deposition rates are heavy according to an Institute of Electrical and Electronic Engineers (IEEE) classification of deposition rates. The area that is most susceptible to mineral deposition is within a 328-ft. (100-m) radius of the MDCTs.

19.4.2.1.2.2.4 Air Dispersion Modeling Assumptions and Results

An air dispersion modeling analysis was performed to estimate the air quality impacts from the new emissions sources. The American Meteorological Society/USEPA Regulatory Model (AERMOD, version 21112) was used to conduct the air quality analysis. The AERMAP terrain data processor (version 18081) was used to extract elevations from the National Elevation Dataset, at 1/3 arc-second resolution, to determine receptor elevations of receptors, buildings, and emissions sources.

Modeling was performed using AERMOD-ready surface and upper-air meteorological data provided by the New Mexico Environment Department (NMED) Air Quality Bureau (AQB) from the Hobbs Station, data for the period 2017 to 2021.

19.4.2.1.2.2.4.1 Model Inputs and Assumptions

Table 19.4.2-5 and Table 19.4.2-6 list the modeled emissions rates and exhaust characteristics used for the evaluation of the three (3) standby diesel generators (SDG 1, SDG 2, and SDG 3), one (1) FWP, and two (2) cooling towers.

19.4.2.1.2.2.4.1.1 Standby Diesel Generators Operating Assumption

Testing for standby diesel generators is performed individually. Therefore, modeling was performed for one standby diesel generator operating.

19.4.2.1.2.2.4.1.2 Cooling Towers Operating Assumptions

Two cooling towers are installed but only one tower is required for operations. The other cooling tower is a spare in the event the other is not available. For conservatism, modeling was performed assuming both cooling towers are operating.

19.4.2.1.2.2.4.2 Model Results

Maximum ground level concentration from the new emissions sources were compared to the NAAQS or NMAAQS, as applicable.

Maximum ground level concentrations for nitrogen dioxide (NO_2), CO, and SO_2 from the standby diesel generators and the FWP are shown in Table 19.4.2-8. The maximum ground level concentrations are based on the NAAQS or NMAAQS averaging period requirements as define below:

- 1-hour (hr.) NO_2: Five-year average of 98th percentile daily maximum 1-hr. concentrations.
- Annual NO_2: Five-year maximum annual average concentration.
- 1-hr. CO: Five-year maximum 1-hr. concentration.
- 8-hr. CO: Five-year maximum 8-hr. concentration.
- 1-hr. SO_2: Five-year average of 99th percentile daily maximum 1-hr. concentrations.

Maximum ground level concentrations for PM_{10} and $PM_{2.5}$ from the cooling towers, standby diesel generators, and the FWP are shown in Table 19.4.2-9. The maximum ground level concentrations are based on the NAAQS or NMAAQS averaging period requirements as define below:

- 24-hr. $PM_{2.5}$: Five-year average of 98th percentile maximum 24-hr. concentrations.
- Annual $PM_{2.5}$: Five-year annual average concentration.
- 24-hr. PM_{10}: Five-year high second high 24-hr. concentration.

Based on this evaluation, the results conclude that the EIPC does not cause or contribute to an exceedance of the NAAQS and NMAAQS.

19.4.2.1.2.3 Greenhouse Gas Emissions

Greenhouse gases (GHGs) trap heat in the atmosphere, absorbing and emitting radiation in the thermal infrared range. The most important of these gases are CO_2, methane, nitrous oxide, and fluorinated gases. GHGs are reported as CO_2-equivalent (CO_2e) and refer to the global warming potential of the GHG or gases being emitted. Activities associated with the proposed EIPC site that are expected to contribute to GHGs include:

- Construction activities at the EIPC site resulting in principally emissions of CO_2; GHG emissions associated with construction activities include the commuting of the construction workforce and operation of construction equipment at the site.
- Plant operational activities associated with the operation of plant equipment and the operations workforce.
- Decommissioning activities associated with the decommissioning workforce and decommissioning equipment.
- Life-cycle activities related to the mining, processing, and transport of materials and waste storage should also be considered as part of the GHG inventory.

Eden will develop a comprehensive program to avoid and control GHG emissions associated with the EIPC. It is expected that this program includes elements such as:

- Developing a GHG emission inventory.
- Investigating and implementing methods for avoiding or controlling the GHG emissions identified in the inventory.
- Encouraging carpooling or other measures to minimize GHG emissions due to vehicle traffic during construction and operation of the EIPC.
- Conducting periodic audits of GHG control procedures and implementing corrective actions, when necessary.

Based on the examinations above and the planned mitigation steps, it is concluded that the impact of GHG (CO_2e) emissions is SMALL.

19.4.2.1.2.4 Mitigative Measures

Emission-specific strategies and measures are developed and implemented to ensure compliance within the applicable regulatory limits defined by the National Primary and Secondary Ambient Air Quality Standards (40 CFR Part 50) and National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61).

Contractors, vendors, and subcontractors are required to adhere to appropriate Federal and state occupational health and safety regulations. These regulations set limits to protect workers from adverse conditions, including air emissions. Implementation of controls and limits at the source of emissions on the construction site results in reduction of potential impacts off-site.

19.4.2.1.2.5 Impacts of Eventual EIPC Decommissioning

Decommissioning is the removal of a nuclear facility from service and to reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. During the eventual decommissioning phase, activities, equipment usage, and their associated emissions are expected to be similar, but less than that of the construction phase as decommissioning activities are expected to be less extensive than construction. Therefore, impacts during the decommissioning phase are SMALL.

19.4.2.1.2.6 Required Permits

As described in Section 19.1.2, in addition to the NRC licensing requirements, construction and operation of the EIPC is subject to a variety of other federal, state, and local environmental regulatory and permitting requirements. This includes an air quality permit application, which will be submitted to NMED. Table 19.1.2-1 lists the permits and other approvals required for construction and operation of the EIPC.

19.4.2.2 Noise

This subsection analyzes noise impacts from construction, operation, and decommissioning of the EIPC site relative to appropriate standards and guidelines.

As detailed in Subsection 19.3.2.2.1, Lea County, NM, where the project site is located, has established a noise-control ordinance prohibiting excessive noise during nighttime hours (between 10:00 p.m. and 6:00 a.m.). Sound projecting from a property during nighttime hours may not exceed 50 A-weighted decibels (dBA) at the boundary of the property. No daytime noise limits are established. Additionally, no other municipal or state ordinances or regulations governing environmental noise are applicable to the project site. The USEPA recommends that day-night average noise levels (L_{dn}) not exceed 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas. In addition, NRC guidance (NUREG-1555, Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan) states that L_{dn} less than 65 dBA outside a residence is acceptable, which is consistent with the U.S. Department of Housing and Urban Development’s regulations for exterior noise standards.

19.4.2.2.1 Impacts of Construction

The EIPC requires the use of heavy equipment for site preparation and construction activities, such as clearing, excavation, and grading. As listed in Subsections 19.2.1.6.1 and 19.2.1.6.4, the types of heavy equipment utilized are similar during both the construction and decommissioning periods. Noise levels from construction and operation were estimated by calculating how noise levels decrease as the distance from the source increases. Noise level at sensitive receptors were obtained from an online noise attenuation calculator (Sengpielaudio, 2022). However, this method does not account for additional sound absorption due to ground cover, vegetation, intervening topography, etc. Levels of sound pressure and levels of sound intensity from a point source decrease by approximately 6 dBA for every doubling of distance. The formula used to calculate noise attenuation includes the sound pressure level at the source, distance of the source sound pressure level, and the distance from the source to the receiver. These inputs allow for the calculation of sound pressure level at the receiver. Construction and operation equipment specifications detail sound pressure level and distance from the sound source. Table 19.4.2-10 provides a representative list of equipment that may be used on-site

and estimated attenuated noise levels for each piece of equipment at various distances. Noise levels applicable to this equipment range from 55 dBA to 85 dBA at a distance of approximately 15 m (50 ft.) from the source, attenuating to 67 dBA or less at approximately 120 m (394 ft.).

Activities associated with construction of the EIPC site features are primarily concentrated toward the center of the property (Figure 19.2.1-4), such that noise levels at the property boundary typically attenuate to levels below those listed in Table 19.4.2-10. However, it is conservatively assumed that the entire site is impacted by construction activities in order to account for any clearing, grading, and access road construction near the property boundary or potential changes to construction plans. Therefore, noise levels within 15 m (50 ft.) of the property boundary may temporarily exceed 85 dBA when heavy equipment is operated adjacent to the boundary. In the event construction activities occur overnight (between 10:00 p.m. and 6:00 a.m.), this could result in exceedances of the Lea County nighttime noise ordinance that limits sound projecting from a property to 50 dBA at the property boundary. However, as shown on Figure 19.3.1-1, adjoining properties consist of undeveloped scrub/shrub and oilfields that do not contain human receptors, especially at night. The closest sensitive receptors are residences located approximately 1.7 mi. (2.7 km) to the west of the project site center. At this distance construction noise attenuates to levels of approximately 42 dBA or less, below both Lea County's nighttime limit and the USEPA's recommended L_{dn} of 55 dBA. Such noise levels are generally not audible over typical background levels for quiet to normal suburban areas where noise levels range from 48 dBA to 57 dBA (USEPA, 1974).

On-site noise level exposure can also be controlled through BMPs, such as appropriate training, personal protective equipment (PPE), and periodic health and safety monitoring. Other industry best practices could include maintenance of noise-limiting devices on vehicles and equipment, controlling access to high-noise areas, limiting the duration of noise emissions, and/or shielding high-noise sources to limit the adverse effects of noise on workers (SHINE, 2015). Thus, the impact of noise from on-site construction activities associated with the EIPC is SMALL.

The project also includes the installation of utilities in an off-site utility corridor (Figure 19.3.1-1). The closest sensitive receptors are described in 19.3.2.2.4, and are residences located 0.27 mi. (0.43 km) and 0.39 mi. (0.63 km) from the corridor on the north and south side of NM-176. Table 19.4.2-10 describes construction noise, which attenuates to levels ranging from 67 to 79 dBA at 30 m and 43 to 73 dBA at 60 m. These levels are above the USEPA's recommended L_{dn} of 55 dBA, however actual impacts may be slightly lower as objects and infrastructure would cause further noise attenuation. Additionally, impacts would be temporary and highest at the western most portion of the corridor and attenuate as the installation occurs along the corridor from west to east. Impacts of noise from the installation of off-site utilities associated with the EIPC are SMALL.

Increased traffic associated with the construction workforce traveling to and from the EIPC as well as the mobilization of heavy equipment also generate noise. As noted in Subsection 19.2.1.5, during the construction phase the estimated number of workers ranges from 26 to 233. The daily commuting workforce plus intermittent equipment mobilization to and from the site increases traffic noise relative to background levels, with the most notable increases associated with the start and stop of daytime shift work when traffic volumes are highest. However, as discussed in Subsection 19.3.7.2.5.4, existing annual average (2019) daily traffic volumes on NM-176 consist of 4801 vehicles and 1311 trucks, some of which are inherently associated with nearby industrial facilities such as URENCO and the Waste Control Specialists (WCS) disposal site (Figure 19.3.1-3). Thus, the number of trips generated by construction of the EIPC is minimal compared with existing traffic flow. In addition, there are no

sensitive noise receptors located along NM-176 in proximity to the project site. The nearest sensitive receptors are located west of NM-18, toward the City of Eunice, NM, where noise from project-related traffic is negligible, as construction-related vehicles disperse into the local transportation network and integrate into typical traffic patterns. Due to the dissipation of traffic noise with distance and the current commercial and industrial usage of the transportation routes, traffic noise impacts associated with construction of the EIPC are SMALL.

Noise control practices at the construction site and the attenuation provided by the distance between the general public and the project site location limit the impact of construction-related noise on the public and workers and, thus, impacts are SMALL and temporary.

19.4.2.2.2 Impacts of Operations

External noise emissions from the EIPC during operations are primarily limited by the walls of the facility and other physical barriers. The only outdoor equipment that produces considerable sound levels are the MDCTs needed for the reactor secondary coolant system. The loudest component of cooling tower noise is the fan discharge, which has a noise level of 74 dBA at 15 m (50 ft.). Based on straight-line noise attenuation, fan noise from the cooling towers, located just south of the RF (Figure 19.2.1-4), attenuates to approximately 44.3 dBA or less at the closest property boundary, below Lea County's nighttime noise limit. Additionally, at the closest residences this cooling tower noise attenuates to levels below 30 dBA, which is inaudible over typical background noise levels. Thus, impacts from on-site noise emissions from the EIPC during operations are SMALL.

Off-site noise generated during facility operations relates primarily to vehicular movements associated with delivery trucks, employee vehicles, and site vehicles. It is conservatively estimated that during operation of the EIPC, approximately 780 vehicles visit the site daily via a driveway off of NM-176, resulting in a two-way volume of 1560 additional trips per day (Bohannan, 2020). Due to the nature of the decibel scale and the attenuating effects of noise with distance, a doubling of traffic volume results in an increase in noise level of approximately 3 dBA, which is not normally a perceptible noise increase (FHWA, 2011). As the 1560 additional trips do not double the traffic volumes on NM-176, increases in traffic noise are anticipated to be negligible along the majority of the roadway. Traffic noise increases along NM-176 at the driveway entrance to the EIPC as vehicles and trucks slow down and speed up from the new intersection. However, there are no sensitive receptors in proximity to this intersection. Therefore, potential noise impacts associated with operations-related traffic are SMALL.

As with construction, the attenuation provided by the distance between the general public and the EIPC limits the impact of on-site operational noise. Additionally, given the anticipated traffic volumes, operations-related vehicles do not have a notable impact on existing traffic patterns in the surrounding community or on traffic noise. For these reasons noise impacts during operations are SMALL.

19.4.2.2.3 Impacts of Decommissioning

At the end of the license term for the EIPC site, the facility is to be decommissioned such that residual radioactivity is reduced to a level that permits release of the site for unrestricted use and termination of the license. Decommissioning activities involve similar heavy equipment to that used during the construction period (Table 19.4.2-10) and, as noted in Subsection 19.2.1.5, require a smaller workforce peaking at approximately 71 full-time workers. Therefore, noise impacts from both the on-site decommissioning activities and the project-related traffic are

expected to be similar to or less than those impacts described for the construction period. Therefore, impacts during the decommissioning period are SMALL.

19.4.2.2.4 Impacts to Wildlife

Wildlife species observed or potentially occurring on or in the vicinity of the EIPC site are detailed in Subsection 19.3.5.7.2. Typical noise-related responses by wildlife may include localized, short-term avoidance of an area during periods of excessive noise emissions (Blickley and Patricelli, 2010). The National Research Council also concluded that wildlife impacts are generally similar to human impacts and that the exposure levels identified to protect humans also protect animals (National Research Council, 1977). For this reason, and because wildlife present in proximity to the EIPC site are generally already habituated to noise levels associated with the adjacent industrial land uses, impacts to wildlife are similar to those described above for the various phases of the project and are SMALL.

Table 19.4.2-1
Standby Diesel Generator Emissions Estimates

Pollutant	Hourly Emissions (lb/hr-engine)	Annual Emissions (tons/year, total for 3 engines)
NO_x	12.7	1.90
CO	6.9	1.04
VOC	0.91	0.14
PM	0.40	0.060
PM_{10}	0.40	0.060
$PM_{2.5}$	0.40	0.060
SO_2	0.011	0.0017
CO_2	1206	180.9

Abbreviations: lb. = pound(s) | hr. = hour(s) | NO_x = nitrogen oxides | CO = carbon monoxide | VOC = volatile organic compound(s) | PM = particulate matter | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | SO_2 = sulfur dioxide | CO_2 = carbon dioxide

Table 19.4.2-2
Diesel-Driven Fire Water Pump Emissions Estimates

Pollutant	Hourly Emissions (lb/hr)	Annual Emissions (tons/year)
NO_x	1.81	0.090
CO	1.58	0.079
VOC	0.68	0.034
PM	0.090	0.0045
PM_{10}	0.090	0.0045
$PM_{2.5}$	0.090	0.0045
SO_2	0.0031	0.00016
CO_2	341.0	17.0

Abbreviations: lb. = pound(s) | hr. = hour(s) | NO_x = nitrogen oxides | CO = carbon monoxide | VOC = volatile organic compound(s) | PM = particulate matter | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | SO_2 = sulfur dioxide | CO_2 = carbon dioxide

Table 19.4.2-3
Total Annual Emissions Estimates[a]

Pollutant	Standby Diesel Generators – 3 total (tons/year)	Diesel Driven Fire Water Pump Engine (tons/year)	Cooling Towers – 2 total (tons/year)	Total Annual Emissions (tons/year)
NO_x	1.90	0.090	--	2.0
CO	1.04	0.079	--	1.1
VOC	0.14	0.034	--	0.17
PM	0.060	0.0045	0.62	0.68
PM_{10}	0.060	0.0045	0.39	0.45
$PM_{2.5}$	0.060	0.0045	0.0013	0.066
SO_2	0.0017	0.00016	--	0.0018
CO_2	180.9	17.0	--	197.9

a) Standby diesel generators and the diesel driven fire water pump assume 100 hr. of operation per year.
Abbreviations: NO_x = nitrogen oxides | CO = carbon monoxide | VOC = volatile organic compound(s) | PM = particulate matter | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | SO_2 = sulfur dioxide | CO_2 = carbon dioxide

Table 19.4.2-4
Cooling Tower Emissions Estimates

Pollutant	Total Hourly Emissions (lb/hr-tower)	Total Annual Emissions (tons/year, total for 2 towers)
PM	0.071	0.62
PM_{10}	0.044	0.39
$PM_{2.5}$	0.00015	0.0013

Abbreviations: lb. = pound(s) | hr. = hour(s) | PM = particulate matter | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm

Table 19.4.2-5
Modeled Emission Rates

Pollutant	Standby Diesel Generators (per engine) (lb/hr-engine)	Diesel Driven Fire Water Pump (lb/hr)	Cooling Towers (per tower) (lb/hr-cell)
NO_x	12.7	1.81	--
CO	6.9	1.58	--
SO_2	0.011	0.0031	--
PM_{10}	0.4	0.09	0.044
$PM_{2.5}$	0.4	0.09	0.00015

Abbreviations: lb. = pound(s) | hr. = hour(s) | NO_x = nitrogen oxides | CO = carbon monoxide | SO_2 = sulfur dioxide | PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm

Table 19.4.2-6
Modeled Exhaust Characteristics for the New Sources

Emission Point ID	Operating Load	Base Elevation (ft.)	Stack Height (ft.)	Stack Diam (ft.)	Exit Velocity (acfm)	Exit Velocity (ft/sec)	Exit Temp (°F)	Stack Location	
								UTM Easting (m)	UTM Northing (m)
SDG 1	100%	3372.4	20	0.68	7344	337.0	883	678921	3589168
SDG 2	100%	3372.4	20	0.68	7344	337.0	883	678921	3589163
SDG 3	100%	3372.4	20	0.68	7344	337.0	883	678921	3589158
FWP	100%	3372.4	15	0.5	1930	163.8	859	678923	3589138
Cooling Tower 1	100%	3372.1	13.7	7.0	72,280	31.3	93.12	679010	3588967
Cooling Tower 2	100%	3372.1	13.7	7.0	72,280	31.3	93.12	679016	3588967

Abbreviations: ft. = feet | acfm = actual cubic feet per minute | ft/sec = feet per second | °F = degrees Fahrenheit | UTM = Universal Transverse Mercator | SDG = standby diesel generator

Table 19.4.2-7
Summary of the SACTI Highest-Modeled Impacts from the Cooling Tower

Impact	Maximum Modeled Impact	Year	Direction from Cooling Towers	Distance from Cooling Towers (m)
Ground fogging	7.3 hr. per year	2022	South	100
Rime icing	3.8 hr. per year	2022	South	100
Mineral deposition	0.28 mg/cm^2-mo	2018	North	100
Plume shadowing	50.4 hr. per year	2022	Southwest	200

Abbreviations: SACTI = Seasonal/Annual Cooling Tower Impact | m = meter(s) | hr. = hour(s)

Table 19.4.2-8
Maximum Modeled Concentrations from Standby Diesel Generators and Diesel-Driven Fire Water Pump Engine for NO_2, CO, and SO_2

Pollutant	Average Period	NAAQS/NMAAQS (micrograms [µg]/cubic meters [m^3])	Maximum Modeled Concentration (µg/m^3)	Background Concentrations (µg/m^3)	Total Concentrations (µg/m^3)	Percent of the NAAQS or NMAAQS	Receptor Location	
							UTM Easting (m)	UTM Northing (m)
NO_2	annual	94.02	5.5	9.30	14.8	16%	678858	3589489
	1-hr.	188.03	110	65.80	176	94%	678858	3589489
CO	8-hr.	9960.10	68	1265	1333	13%	678858	3589489
	1-hr.	14,997.50	80	2148	2228	15%	678858	3589489
SO_2	1-hr.	196.4	0.13	3.5	3.60	2%	678858	3589489

Abbreviations: NAAQS = National Ambient Air Quality Standards | NMAAQS = New Mexico Ambient Air Quality Standards | m^3 = cubic meter(s) | µg = microgram(s) | UTM = Universal Transverse Mercator | m = meter(s) | NO_2 = nitrogen dioxide | hr. = hour(s) | CO = carbon monoxide | SO_2 = sulfur dioxide | CO_2 = carbon dioxide

Table 19.4.2-9
Maximum Modeled Concentrations from Cooling Towers, Standby Diesel Generators, and Diesel-Driven Fire Water Pump Engine for PM_{10} and $PM_{2.5}$

Pollutant	Average Period	NAAQS/NMAAQS ($\mu g/m^3$)	Maximum Modeled Concentration ($\mu g/m^3$)	Background Concentrations ($\mu g/m^3$)	Total Concentrations ($\mu g/m^3$)	Percent of the NAAQS or NMAAQS	Receptor Location	
							UTM Easting (m)	UTM Northing (m)
$PM_{2.5}$	annual	12	0.201	7.1	7.30	61%	678858	3589489
	24-hr.	35	1.08	16.5	17.58	50%	678810	3589488
PM_{10}	24-hr.	150	2.03	37.3	39.3	26%	678799	3589506

Abbreviations: PM_{10} = particulate matter with an aerodynamic diameter less than 10 µm | $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than 2.5 µm | NAAQS = National Ambient Air Quality Standards | NMAAQS = New Mexico Ambient Air Quality Standards | µg = microgram(s) | m^3 = cubic meter(s) | UTM = Universal Transverse Mercator | m = meter(s) | hr. = hour(s)

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Table 19.4.2-10
Attenuated Noise Levels Expected for Operation of Representative Construction and Decommissioning Equipment

Source	Attenuated Noise Levels (dBA)			
	15 m (50 ft.)	30 m (98 ft.)	60 m (197 ft.)	120 m (394 ft.)
Air Compressor	80	74	68	62
Auger Drill Rig	85	79	73	67
Backhoe	80	74	68	62
Compactor	80	74	68	62
Concrete Mixer Truck	85	79	73	67
Concrete Pump Truck	82	76	70	64
Crane	85	79	73	67
Dozer	85	79	73	67
Dump Truck	84	78	72	66
Excavator	85	79	73	67
Flatbed Truck	84	78	72	66
Front-End Loader	80	74	68	62
Generator	82	76	70	64
Grader	85	79	73	67
Lift	85	79	73	67
Pickup Truck	55	49	43	37
Welding Equipment	73	67	61	55
All Other Equipment >5 Horsepower	85	79	73	67

Source: FHWA, 2016.
Note: Distances shown are the distances from the noise source.
Abbreviations: dBA = A-weighted decibel(s) | ft. = feet

19.4.3 GEOLOGIC ENVIRONMENT

19.4.3.1 Impacts of Large-Scale Hazards

Geological conditions and other natural hazards may exert an effect on the EIPC. Factors considered in the vicinity of the project site relative to construction, operation, and decommissioning of the EIPC are described in Subsection 19.3.3.5 and Subsection 19.3.3.6 and include the following:

- Volcanic Activity. Because no active volcanoes or any that have demonstrated recent activity exist in the vicinity of the project site, volcanoes pose no threat to the EIPC (Subsection 19.3.3.6.2).
- Tsunami Threats. The EIPC project site is remote from any large body of water and no recorded tsunamis are reported in the vicinity surrounding the project site. Tsunamis, therefore, present no threat to the EIPC (Subsection 19.3.3.6.1).
- Landslide Potential. No reported landslides are recorded for Lea County or nearby areas of Texas; therefore, landslides pose no threat to the EIPC (Subsection 19.3.3.6.3).
- Earthquakes. As discussed in Subsection 19.3.3.5, the EIPC is located in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the project site is low. The majority of earthquakes in the United States occur in the tectonically active western portion of the country; however, states in the southwest, such as New Mexico, can also experience earthquakes, although at a lower rate of occurrence and at lower intensities. Earthquakes in the area around the proposed project site include isolated and small clusters of events of low-to-moderate size toward the Rio Grande Valley of New Mexico and in Texas, southeast of the project site.

  As part of the safety analysis, a review of seismic activity near the site, including earthquakes and faults, is performed . The design-basis earthquake is determined and used in the design of the facilities. Soils with properties that result in loss of strength during a seismic event are removed and replaced or remediated to preclude loss of strength during a seismic event.

Consequently, impacts on the EIPC from large-scale hazards are SMALL.

19.4.3.2 Other Impacts on Soils and Geology

This subsection summarizes known and potential geological impacts and mitigation measures. Impacts to geology and soils are determined by assessing potential changes that could result from construction and operation of the EIPC.

19.4.3.2.1 Impacts on Soils

The EIPC consists of the EMIF building, operational and administrative support structures, evaporation and stormwater ponds, parking and roadways, and utilities infrastructure. The depths of excavation required for these facilities are listed in Table 19.4.3-1.

19.4.3.2.1.1 Construction

Construction activities entail excavation and grading within the project footprint including the off-site utility corridor as depicted in Figure 19.3.1-1. Based on the preliminary grading analysis of the site, approximately 212,693 cubic yards (yd^3) (162,615 cubic meters [m^3]) of soil is excavated to support construction activities. Approximately 132,616 yd^3 (101,392 m^3) is considered suitable for reuse as fill and is stockpiled on-site. Caliche is unsuitable for use in construction, and approximately 80,077 yd^3 (61,223 m^3) is removed during construction and disposed at an approved existing off-site landfill location. The total fill required for construction is approximately 180,136 yd^3 (137,723 m^3). This volume accounts for the reuse of suitable soils excavated from the site and the transport of approximately 47,520 yd^3 (36,331 m^3) from an existing permitted off-site borrow area.

Materials are stockpiled on level or only gently sloped lands to minimize erosion. Where slopes are steeper, appropriate erosion control measures, including berms, are used to minimize erosion. Other BMPs implemented as erosion prevention and sediment controls include silt fences, stone or hay bale check dams, concrete truck wash containment, stabilized construction entrance, and temporary seeding and erosion control blankets.

A Phase I Environmental Site Assessment (performed by NV5 in 2020) was conducted to identify the potential occurrence of contaminated soils or other issues of concern at the project site. This investigation included examination of the project site for storage tanks, drums, transformers containing polychlorinated biphenyls, stained soil, stressed vegetation, and other evidence of environmental contamination. As a result, no issues of concern are identified that may affect soils of the EIPC project site.

Soil disturbance is limited to the EIPC project site and off-site utility corridor, and BMPs are implemented to minimize soil erosion on the site. Therefore, impacts to soils are SMALL.

19.4.3.2.1.2 Operations

Impacts to shallow soils after construction is complete and during operation of the EIPC does not occur. Therefore, no impacts to soils or erosion occur during facility operation.

19.4.3.2.1.3 Decommissioning

As described in Subsection 19.2.1.2.5, decommissioning of the EIPC is conducted in accordance with NRC license termination requirements. Soil testing is conducted to identify areas potentially contaminated by site activities. Soils with elevated levels of constituents of concern are addressed by excavation and removal or other mitigative measures, as appropriate, in accordance with NRC and USEPA guidelines. Decontamination and decommissioning are also conducted to minimize soil erosion, compaction, and alteration of on-site drainage patterns, to the extent practicable. Soils of concern are excavated and removed from the EIPC project site and are transported to an appropriate licensed disposal facility. Therefore, impacts to shallow soils upon completion of the decontamination and decommissioning process are SMALL.

19.4.3.2.1.4 Mitigation Measures

As previously stated, impacts to site soils are SMALL. The practices and measures used to further control these impacts to soils during construction and to minimize residual impacts include the following:

- Soil materials are placed within stockpiles on level or only gently sloped lands to minimize erosion. Where slopes are steeper, appropriate erosion control measures, including berms, are used to minimize erosion. Other BMPs implemented as erosion prevention and sediment controls include silt fences, stone or hay bale check dams, concrete truck wash containment, stabilized construction entrance, and temporary seeding and erosion control blankets.
- Following completion of the facility, the temporary construction laydown/parking area is graded as needed to reverse the effects of compaction and replanted with noninvasive herbaceous plant species.
- Soils with elevated levels of constituents of concern are addressed by excavation and removal or other mitigative measures, as appropriate, in accordance with NRC and USEPA guidelines.
- Only unsuitable soils excavated from the EIPC project site are transported to an appropriate licensed disposal facility.
- An approved Decommissioning Plan is established and implemented for ultimate NRC release of the site for unrestricted use and license termination.

19.4.3.2.2 Geological Impacts

As indicated in Subsection 19.3.3.3, the geologic formations of interest at the EIPC project site from oldest to youngest (i.e., from deepest to most shallow) include the Triassic Age Dockum Group, the undifferentiated Ogallala/Antlers/Gatuña Formation, the Pleistocene Age Blackwater Draw Formation, and the Holocene Epoch windblown sands and playa deposits, as well as caprock caliche. Five formations together form the Dockum Group, of which the Santa Rosa, Tecovas, Trujillo, and Cooper Canyon Formations are present beneath the project site. The Santa Rosa Formation sandstone at the base of the Dockum Group is approximately 250 ft. (76 m) thick, and the top of the formation is approximately 1140 ft. (347 m) below the ground surface. Beneath the topsoil is a variable sequence of calcium carbonate-cemented caliche (i.e., the caprock caliche). The caprock caliche thickness varies but can reach up to 12 ft. (3.7 m). Thin layers of sand overlay the caliche.

19.4.3.2.2.1 Construction and Operations

Construction activities involve the placement of foundations into the surficial soils and caprock caliche that underlie the EIPC project site. No blasting is expected to be required for construction. Local hazards are those associated with site-specific properties of the soil and caliche.

In addition to the large-scale hazards described in Subsection 19.4.3.1, potential operational-phase impacts include those associated with sinkhole formation.

As summarized in Subsection 19.3.3.6, no karst features are reported as occurring directly on the EIPC project site. Considering the data, there is no identified risk from karst associated with

the dissolution of surface carbonate formations, but there is a minor potential for risk associated with deeper evaporative rock formations in conjunction with the long history of oil and gas exploration and production in Lea County. Because the characteristics of existing wells (e.g., well casing integrity) adjacent to and near the project site are unknown, there is some minor potential for risk to the EIPC associated with the dissolution of deeper evaporative rock formations during the long term. Any possible subsidence would generally occur in a slow wide-ranging area due to oil and gas extraction. A settlement monitoring program established during construction is able to evaluate the long-term potential from subsidence during the life of the plant. Remedial measures are then developed and instituted based on the findings of the monitoring program. Therefore, impacts to geologic resources during construction and operations are SMALL.

19.4.3.2.2.2 Decommissioning

As described in Subsection 19.2.1.2.5, decommissioning of the EIPC is conducted in accordance with applicable NRC license termination requirements. Subsurface soil testing may also be part of the process, as appropriate, to demonstrate that any residual subsurface soil impacts meet NRC and USEPA guidelines. Impacts to subsurface soils upon completion of the decontamination and decommissioning process are expected to be SMALL.

19.4.3.2.2.3 Mitigation Measures

As previously stated, potential geological impacts to and from the EIPC are SMALL. The facility is constructed and operated in accordance with appropriate geotechnical and structural specifications, engineering design criteria, applicable building codes, and relevant NRC regulatory guidance.

Additionally, groundwater is at a great depth, and the existing soils are dense sands and very stiff clays. Thus, there is minimal liquefaction potential during a seismic event. There are no Quaternary faults in the general area, and seismic activity is low. Thus, the need for mitigative measures is not anticipated.

19.4.3.2.3 Impacts to Rare or Unique Geologic Resources

As described in Section 19.3.3, no rare or unique geologic resources are identified in the vicinity of the EIPC project site. Therefore, impacts to rare or unique geologic resources are SMALL.

Table 19.4.3-1
Depth of Excavation for EIPC Infrastructure

Site Feature	Depth of Excavation
General building foundation	3 ft. below finish grade
EMIF building	18 ft. (basement)
RF portion of EMIF	35 ft. (approximate)
Roadway	20 in. (roadway bed)
Stormwater pond	20 ft.
Underground utilities	5 ft. (average)
Evaporation pond	6 ft.

Abbreviations: EIPC = Eden Isotope Production Complex | ft. = feet | EMIF = Eden Medical Isotope Facility | RF = Reactor Facility

19.4.4 WATER RESOURCES

19.4.4.1 Hydrology

19.4.4.1.1 Surface Water

19.4.4.1.1.1 Facility Construction

The site and off-site utility corridor are depicted in Figure 19.3.1-1. The Phase I Environmental Site Assessment (performed by NV5) did not identify any surface water features, such as creeks, streams, or ponds, present on or in the immediate area surrounding the EIPC project site or the off-site utility corridor. Therefore, there are no direct effects to surface water resources from construction.

Federal, state, and local regulations and permit procedures provide minimum requirements for stormwater management during construction activities to prohibit adverse impacts to surface water or stormwater. Because construction requires coverage under a construction general permit in accordance with 40 CFR 450.10, a Stormwater Pollution Prevention Plan (SWPPP) is prepared to establish BMPs to minimize stormwater-related erosion on-site and to mitigate the potential indirect impacts associated with the release of sediment from stormwater runoff into off-site areas. Fuel storage associated with construction is within secondary containment, minimizing the potential for releases to the environment. On-site oil storage during construction requires a Spill Prevention, Control, and Countermeasure (SPCC) Plan in accordance with 40 CFR Part 112. The SPCC Plan details requirements for oil spill prevention, preparedness, and response to prevent oil discharges. Stormwater runoff in the project area flows to the southwest of the project site, per the Phase I Environmental Site Assessment (performed by NV5 in 2020). Stormwater runoff during construction activities is collected by interceptor ditches within the construction laydown area and discharged to the existing natural drainage course to the southwest of the site, as described in Subsection 19.2.2.4.3.1. Stormwater flow is dispersed by a level spreader to prevent downstream erosion.

No surface water features are present on or in the immediate vicinity of the project site and BMPs are used to minimize stormwater runoff. Therefore, indirect impacts to surface water hydrology from construction of the EIPC are SMALL.

19.4.4.1.1.2 Facility Operations

As described above, no surface water features are present on the project site or in the immediate vicinity. As described in Subsection 19.2.6.1.1, an approximately 13-acre-feet (ac-ft) (16,040-m^3) evaporation pond, with a bottom length of 620 ft. (189 m), a bottom width of 315 ft. (96 m), and a depth of 6 ft. (1.8 m), collects cooling tower blowdown and liquid discharge from the liquid effluent control system (LECS). The evaporation pond is sized, with 3 ft. (1 m) freeboard, for inflow due to a 100-year storm event in addition to the normal plant discharge inflow. The freeboard is provided to accommodate storm events more severe than the 100-year storm event, such as the Probable Maximum Precipitation (PMP) event. As described in Subsection 19.2.2.4, all water used at the EIPC is obtained from the Eunice, NM, municipal water supply and normal sanitary wastewater is discharged to the Eunice wastewater system. Therefore, direct impacts to surface water from facility operations are SMALL.

During operations, stormwater runoff is mitigated through the use of a stormwater retention pond located on the west side of the project area west of the EIPC structures (Figure 19.2.1-4).

Stormwater is collected from impervious surfaces, such as buildings, roads, and pads, discharged into the storm sewer system and directed to the stormwater retention pond. Positive surface drainage is maintained for EIPC buildings, as described in Subsection 19.2.1.4.1. As stated in Subsection 19.2.2.4.3.1, the stormwater system is designed for 25- and 100-year rainfall events, as required by Lea County, NM, regulations. The design also addresses New Mexico regulations for retention of runoff during 2-year, 24-hr. storm events to maintain water quality. On-site fuel storage requires an SPCC Plan in accordance with 40 CFR Part 112 that details requirements for oil spill prevention, preparedness, and response regarding oil discharges during operations. As described in Subsection 19.2.2.4.1, during facility operations, on-site fuel is stored in multiple aboveground, or underground, double-walled diesel fuel storage tanks.

The evaporation pond on-site is designed to not overflow during a PMP event, and all stormwater runoff is managed through the use of design controls and a stormwater retention pond. Therefore, indirect impacts to surface water hydrology from facility operations are SMALL.

19.4.4.1.1.3 Facility Decommissioning

As described above, no surface water features are present on or in the immediate vicinity surrounding the EIPC site. As a result, there are no direct effects from decommissioning on surface water resources.

Decommissioning activities are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, a SWPPP is required to mitigate the potential indirect impacts associated with the release of sediment and other runoff to off-site areas. On-site fuel storage during decommissioning requires an SPCC Plan in accordance with 40 CFR Part 112 that details requirements for oil spill prevention, preparedness, and response regarding oil discharges. As identified in Subsection 19.2.2.4.3.1, stormwater runoff is directed to the stormwater retention pond located on the west side of the project area west of the EIPC structures.

During decommissioning, dewatering is not required because all buildings are located above the groundwater level. Therefore, dewatering effluent has no effect on surface water flow characteristics.

Because there are no surface waters in the immediate vicinity of the EIPC site, the evaporation pond on-site is designed to not overflow during a PMP event, and the impacts of decommissioning activities are mitigated through a SWPPP, indirect impacts to surface waters from decommissioning the EIPC are SMALL.

19.4.4.1.2 Groundwater

19.4.4.1.2.1 Construction, Operations, and Decommissioning

Construction of the EIPC includes excavations for building construction, basements, and the belowground RF. In accordance with Subsection 19.2.1.4.1, construction excavation is minimal, less than 2 m (6.5 ft.) deep in most areas, including buildings, adjacent pads, and utility trenches. Deeper excavations are required for construction of basements and the RF. The deepest excavation is for the reactor portion of the EMIF, which is 35 ft. (10.7 m) below grade. Based on data from private wells within 1 mi. (1.6 km) of the project site, the depth to groundwater in the project vicinity ranges from 16 ft. to 241 ft. (4.9 m to 73.5 m). As described in

Subsection 19.3.4.1.2.3, the water well, with a reported depth to water at 16 ft. (4.9 m), is related to a localized, discontinuous, shallow perched saturation zone not associated with an aquifer, as described in NUREG-1790, Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico. This zone exists in the vicinity of the project site within properties to the northeast, near the Wallach Concrete, Inc. and Sundance Services, Inc. facilities. Of the three closest water wells that report depth to water, all within 1 mi. (1.6 km) of the site, depth to water ranges from 39 ft. to 241 ft. (11.9 m to 73.5 m). Excavations required for the EIPC are not located near these areas of saturation; they occur near the center of the EIPC site (Figure 19.2.1-4). Consequently, there is no direct impact to groundwater flow as a result of deep excavations.

No groundwater withdrawals and no groundwater returns are anticipated during construction, operations, or decommissioning. Construction-phase dewatering is not required because the depth to groundwater described in Subsection 19.3.4.1.2.3 exceeds the shallow excavations required for construction and because the permeable soils described in Subsection 19.3.3.4 do not retain rainwater.

All water used by the EIPC is obtained through the Eunice municipal water supply. Sanitary wastewater is discharged directly to the Eunice wastewater system. All other wastewater is routed to the evaporation pond. The evaporation pond is adequately lined in accordance with New Mexico requirements such that there is no impact to groundwater quality. Therefore, direct and indirect impacts to groundwater at the EIPC are SMALL.

19.4.4.2 Water Use

Average estimated water usage by the EIPC during operations is 20.2 million gallons per year (MGPY) (76.5 million liters per year [MLPY]) (i.e., 61.9 ac-ft/year). All water for construction, operations, and decommissioning is supplied by the City of Eunice municipal water supply.

19.4.4.2.1 Surface Water

As described in Subsection 19.2.2.4, all water used at the EIPC during construction, operations, and decommissioning is obtained from the City of Eunice municipal water supply, and normal sanitary wastewater discharges are sent directly to the Eunice wastewater system. Liquid discharge from the LECS is monitored and if it does not meet evaporation pond discharge permit requirements, temporary water treatment skids are utilized to remove radioisotopes and/or hazardous materials, as described in Subsection 19.2.7.1.1. In accordance with Subsection 19.2.2.6, water that is considered acceptable for discharge is routed to the evaporation pond.

There is no surface water used by the EIPC. Additionally, there is minimal release of water from the facility to the adjacent environment that impacts surface water systems. Therefore, direct impacts to surface water from water use during plant construction, operations, and decommissioning are SMALL.

19.4.4.2.2 Groundwater

Construction, operations, and decommissioning activities are not supported by the direct extraction of groundwater on-site. As a result, there are no direct impacts to groundwater on the EIPC site, off-site utility corridor, or in the immediate vicinity.

Water utilized on-site is for both consumptive and non-consumptive uses and is obtained from the City of Eunice municipal water supply. As described in Subsection 19.3.4.2.3, the Eunice municipal water supply draws water from the High Plains Aquifer within the Lea County Underground Water Basin (UWB) (LCWUA, 2000). The approximate daily per capita water use for Eunice is 351 gallons (gal.) (1328.7 liters [L]) (Magnuson et al., 2019). As described in Subsection 19.3.7.2.5.1, Eunice has water rights to 3292 ac-ft/year (406.1 hectare-meters [ha-m]/year). The Eunice municipal water supply also provides part of the water used at URENCO's enrichment facility (Magnuson et al., 2019). Subsection 19.3.4.2.3, details that the total capacity for the Eunice public water supply is approximately 4.0 million gal. per day (MGD) (15.1 million liters per day [MLD]), with a daily average usage of 1.5 MGD (5.7 MLD). As described in Subsection 19.3.4.2.2, projected water demand in Lea County, NM, by 2060, based on a projected annual population growth rate of 0.36 percent to 0.98 percent, ranges from 185,125 ac-ft to 208,490 ac-ft (232 million m^3 to 258 million m^3) per year. The Lea County UWB is predicted to experience a drawdown of 29.5 ft. to 51.1 ft. (9 m to 15.6 m) by 2060, depending on the method of estimation and assumed levels of precipitation (NMISC, 2016). While the demand from the UWB exceeds the recharge rate resulting in a net drawdown of the aquifer, the demand for the EIPC of 20.2 MGPY (76.5 MLPY) represents a small fraction of the total water use from Lea County (approximately 0.03 percent of the projected Lea County water demand of 185,125 ac-ft/year [22,834 ha-m/year]). As a result, indirect impacts of EIPC water use on groundwater as well as the impact on other water users of the High Plains Aquifer are considered SMALL. However, given the nature of water resources in the Southwest and the current depletion of the High Plains Aquifer within Lea County, water conservation measures are being employed during both construction and operations to the extent practical. These include, but are not limited to, using native landscaping that does not require irrigation and installing low-flow plumbing fixtures.

19.4.4.3 Water Quality

Potential surface water- and groundwater-quality impacts from construction, operation, and decommissioning of the EIPC are discussed in this subsection.

19.4.4.3.1 Surface Water

No surface water features are present within the off-site utility corridor or in the immediate vicinity. The evaporation pond on-site is designed to not overflow during a PMP event and as a result, there are no direct impacts to surface water quality from construction, operation, or decommissioning of the EIPC.

Indirect impacts to surface water quality are related to stormwater and pollutant runoff within the project area. Potential indirect surface water quality impacts from facility construction and decommissioning are similar to those of construction of any typical industrial or commercial facility in the area. Erosion and sediment control for ground-disturbing activities meets or exceeds regulatory requirements, including the Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) regulations.

In accordance with Subsection 19.2.2.4.3.1, an on-site stormwater retention pond located to the west of the EIPC structures mitigates adverse impacts of stormwater runoff on-site during plant operation. Stormwater is collected from impervious surfaces, such as buildings, roads, and pads, into the storm sewer system and directed to the stormwater retention pond. The design of the facility, including the construction of a stormwater retention pond, addresses New Mexico regulations for maintaining water quality for 2-year, 24-hr. storm events.

Potential release of construction activity pollutants (e.g., petroleum products, adhesives, and paint) is minimized through the use of an SPCC Plan as required by 40 CFR Part 112. Additionally, federal regulations and permit requirements address management and control of all potential pollutants through the use of structural and nonstructural BMPs, such that release of materials to off-site surface waters is minimized.

During operation, liquid discharge from the LECS includes wastewater from areas where radioactive or hazardous materials may be present, including floor drains in the RF and HCF and emergency showers in the HCF. This wastewater is monitored and if it does not meet evaporation pond discharge permit requirements, temporary water treatment skids are utilized to remove radioisotopes and/or hazardous materials, as described in Subsection 19.2.7.1.1. Water that is considered acceptable for discharge is routed to the evaporation pond.

Impacts to surface water quality from EIPC construction, operations, and decommissioning are SMALL.

19.4.4.3.2 Groundwater

19.4.4.3.2.1 Construction, Operations, and Decommissioning

Because construction, operations, and decommissioning activities are not supported by the direct extraction of groundwater on-site, direct impacts to groundwater quality are not anticipated.

Possible indirect impacts to groundwater quality can occur during construction, operations, or decommissioning. These impacts are related to spills from vehicles, equipment, or storage areas that penetrate hard surfaces or are accidentally released to pervious surfaces and migrate to groundwater prior to detection and remediation. To reduce the occurrence of incidental spills, all equipment and storage areas comply with the appropriate regulations requiring secondary containment of stored liquids and materials, as per the SPCC Plan.

Design characteristics and use of the on-site evaporation pond are described in Subsection 19.2.6.1.1. Construction of the evaporation pond will be permitted and adhere to NM Code 19.15.36.17, which details specific engineering requirements for evaporation ponds, such as liners and leak detection systems, to protect the environment including groundwater. Additionally, operation of the evaporation pond adheres to NM Code 19.15.36.17, which details operational and maintenance requirements and procedures.

Underground systems are described in Subsection 19.2.2.6 and include an underground pipeline system for wastewater and underground fuel storage. An underground pipeline system is used to transport to the LECS wastewater from areas where radioactive and/or hazardous chemicals may be present, including floor drains in the RF and HCF and emergency showers in the HCF. These pipelines are equipped with leak-detection devices to immediately identify spills. Oil storage associated with facility operations includes a double-walled diesel fuel storage tank that provides 8000 gal. (30,300 L) of fuel storage. The storage tank(s) may be located either underground or aboveground. Fuel storage associated with construction and/or decommissioning is within secondary containment, minimizing the potential of releases migrating through the subsurface and impacting groundwater. Oil storage on-site requires an SPCC Plan in accordance with 40 CFR Part 112. The SPCC Plan details the requirements for oil spill prevention, preparedness, and response regarding oil discharges.

The HCF, described in Subsection 19.2.4.1, includes a basement for the long-term staging of full waste drums within a shielded canyon (the waste storage canyon). The waste storage canyon contains waste that has been neutralized and then solidified with other waste generated in the hot cells. This waste is stored in a solidified form, decreasing the likelihood of leakage. Because waste is neutralized and solidified, it is unlikely to leak into groundwater systems.

Measured groundwater levels are below the deepest excavation during construction and decommissioning and below the base of the lowest basement, which prevents any direct impacts to groundwater, as described in Subsection 19.4.4.1.2.1.

Due to the use of appropriate management and control measures discussed above and the depth of groundwater below the EIPC site, direct and indirect impacts to groundwater quality are SMALL.

19.4.4.4 Monitoring

Groundwater monitoring stations are positioned at appropriate locations on the EIPC project site. Specific details regarding the number and locations of groundwater monitoring stations, as well as monitoring frequencies and parameters, will be provided in the Operating License Application.

As noted in Subsection 19.4.4.3.2.1, the on-site evaporation pond, once constructed, has a leak detection system as required by NM Code 19.15.36.17. The leak detection system consists of a properly designed drainage, collection, and removal system placed between an upper and lower liner in a depression and sloped so as to facilitate the earliest possible leak detection. This system is monitored to prevent leakage and protect groundwater systems.

Because of the absence of direct impacts to surface water, the low potential for indirect impacts, and the use of management measures and controls to prevent releases to surface water, no surface water monitoring activities are planned for the EIPC site.

19.4.5 ECOLOGICAL RESOURCES

This section addresses the impact of construction, operations, and decommissioning on the ecological resources on and within the vicinity of the EIPC. The impacts discussed below are based on the characterization and description of terrestrial and aquatic ecosystems within the EIPC site and near-site region from Section 19.3.5. The region surrounding the EIPC site is defined in Subsection 19.3.1.1.2 as the area within a 5-mi. (8-km) radius of the site center point. This region spans Lea County, NM, and Andrews County, TX.

The ecological resources described in Section 19.3.5 are based on a 2020 biological desktop review of the project site and ecological assessments at the neighboring URENCO site (1.3 mi. [2.1 km] north of the project site) and proposed consolidated interim storage facility site (3.0 mi. [4.8 km] northeast of the project site) (NUREG-1790; Cox McLain Environmental Consulting, 2019). No on-site ecological studies or monitoring programs have been implemented at the EIPC site. Consultations with the U.S. Fish and Wildlife Service (USFWS), New Mexico Department of Game and Fish (NMDGF), and Texas Parks and Wildlife Department (TPWD) are scheduled to acquire information regarding ecological resources within and near the project site. Consultation letters from USFWS, NMDGF, and TPWD were received (Appendix 19A), and information from them is incorporated in the sections below.

Impacts evaluated consist of effects from activities associated with construction, operations, and decommissioning, including excavation, grading, temporary staging and construction laydown, and construction of permanent features. This evaluation indicates the magnitude of potential impacts and whether mitigation measures are required.

As described in Section 19.3.5, the EIPC site including easement consists of a 245.6-ac. (99.4-ha) parcel that has been impacted by the grazing of domestic livestock. The surrounding area is impacted by construction and operation of railroads and highways. Nearly the entire site consists of scrub/shrub habitat, with 0.01 percent consisting of developed low-intensity land cover (Dewitz, 2021). While there have been no on-site ecological studies implemented at the project site, expected species and species diversity on-site is limited due to this history of disturbance. Post-construction ecological monitoring is not planned at this time but may be implemented in the future (see Subsection 19.4.5.3).

19.4.5.1 Impacts from Construction

This subsection describes the potential construction-related ecological impacts to the EIPC site and near off-site areas based on the EIPC site layout (see Figure 19.2.1-4). Activities such as land clearing, road installation, temporary and permanent fence installation, and construction-related traffic generate potential disturbances to ecological resources during the construction phase of the EIPC. Figure 19.2.1-4 depicts the proposed buildings and associated infrastructure for site construction. Land may be cleared for construction purposes, but the project does not involve clearing along stream banks, dredging, or disposal of dredged material.

The off-site utility corridor, depicted in Figure 19.3.1-1, is comprised of scrub/shrub habitat on previously disturbed land that is temporarily impacted for utility installation. These temporary impact areas are restored using native herbaceous species.

Of the 245.6 ac. (99.4 ha) comprising the EIPC project area, including easement, construction permanently converts 55.7 ac. (22.5 ha) of scrub/shrub habitat to industrial facilities (Table 19.4.5-1). As described in Subsection 19.2.1.1, permanent conversions to industrial

facilities include the construction of facility buildings, parking lot, cooling towers, electrical substation, stormwater runoff pond, evaporation pond, and drainage channels. Direct construction impacts also include the temporary impact of 37.5 ac. (15.2 ha) of habitat used for construction parking area, construction materials staging or laydown area, and utilities installation. Among the seven different Southwest Regional Gap Analysis Project (SWReGAP) land cover classes identified in Subsection 19.3.5.2, five of the classes are affected by both permanent and temporary disturbance (Table 19.4.5-1) (Lowry et al., 2005). Temporarily impacted areas are restored using native, low-water consumption vegetation. Erosion control includes site stabilization with native grass species, pavement, and crushed stone. Other mitigation measures to reduce impact to ecological resources are discussed below.

19.4.5.1.1 Places and Entities of Special Interest

As described in Subsection 19.3.5.4, no known places or entities of special interest, including wetlands, exist on the project site (NMDGF, 2022a). Places of special interest off-site include National Public Lands, and areas with high rankings of crucial habitat as determined by the Western Association of Fish and Wildlife Agencies (USGS GAP, 2022; State Wildlife Agencies of the Western United States, 2022). These lands are not expected to be impacted by construction.

As depicted in Figure 19.3.1-1, the off-site utility corridor crosses portions of New Mexico State Trust Land. Impacts to New Mexico State Trust Land are temporary and associated solely with utility installation. As described in Subsection 19.3.5.4, there is no mandate for biodiversity protection in New Mexico State Trust Land. Additionally, the utility corridor has been previously disturbed by prior utility and infrastructure development.

In summary, impacts to places and entities of special interest from construction are SMALL because such ecological resources are not present on-site and because the identified off-site resources are not impacted by construction on the EIPC site. Specific mitigation measures and management controls are not needed.

19.4.5.1.2 Aquatic Communities and Wetlands

As described in Subsection 19.3.5.5, no permanent surface water features are present within the project site. Surface water resources near the project site are depicted in Figure 19.3.4-2. None of the surface water features within the 5-mi. (8-km) region support aquatic communities. Further, Subsection 19.3.5.6 reports that wetlands are not present within the project site , and only 31.2 ac. (12.6 ha) of emergent wetlands and 95.7 ac. (38.7 ha) of scrub/shrub wetlands (Figure 19.3.4-2) exist within the project region. Additionally, a land disturbance permit and associated SWPPP is necessary during construction to protect regional wetland communities and surface water features. As no permanent surface water features with aquatic communities are present near the project site and no wetlands are present within the project site, impacts from construction on aquatic communities and wetlands are SMALL.

19.4.5.1.3 Terrestrial Communities

As summarized in Table 19.4.5-1, direct construction impacts permanently convert 55.7 ac. (22.5 ha) of scrub/shrub habitat to industrial facilities, including facility buildings, parking lot, facility access road, electrical power substation, stormwater runoff pond, evaporation pond, drainage channels, firewater tank, and truck washing station. Construction impacts also include the direct temporary impact of 37.5 ac. (15.2 ha) of scrub/shrub habitat for construction

laydown, parking and utility installation. Temporarily impacted areas are restored using native, low-water consumption vegetation and erosion control measures are implemented as necessary. As recommended by NMDGF, post-construction restoration is performed using regionally sourced native seed with an emphasis on enhancing pollinator habitat (Appendix 19A).

The terrestrial communities on the EIPC site and near-site areas are described in Subsection 19.3.5.7. Wildlife potentially affected by construction include bird, mammal, and/or herpetofauna species that occasionally use the site as a travel corridor or for foraging and resting (Subsection 19.3.5.7.2). Wildlife occurrence and use on the EIPC site is limited due to past grazing disturbance, lack of diverse habitat types (nearly all scrub/shrub), and lack of water resources on-site.

As the SWReGAP does not cover Texas, habitat impact in the surrounding area (within a 5-mi. [8-km] radius around the project site center point) must be derived from the NLCD. As described in Subsection 19.4.1.1.1, the loss of scrub/shrub land to industrial facilities is minor when compared with the 46,225 ac. (18,706 ha) of scrub/shrub habitat remaining within a 5-mi. (8-km) radius of the site (see Table 19.4.1-1) (Dewitz, 2021). As such, impacts to wildlife and terrestrial communities from construction are SMALL.

As described in Subsection 19.3.5.7.2, a variety of species of greatest conservation need (SGCN) are present in Lea County and Andrews County (NMDGF, 2022b; TPWD, 2023; Table 19.3.5-7). Most mammal and herpetofauna SGCN present in the county are not expected to occur on the project site due to prior disturbance or lack of habitat. Some birds identified as SGCN may occur on the project site. Impacts on avian species are discussed below. Potential habitat for one reptile SGCN, the western massasauga (*Sistrurus tergeminus*), occurs on the site, but surveys at facilities in the surrounding area have not detected this species, so it is not expected to occur on the site.

Monarch butterflies (*Danaus plexippus*) are candidates for federal listing that are documented in Lea County. This species could be present on the project site and may be affected by construction. Although monarchs could encounter construction traffic on-site, their host plant, milkweed, is not documented at surrounding sites.

Because of their significance as game species, mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) are identified in Subsection 19.3.5.7.2.1 as economically important large mammal species that have the potential to occur on the project site. Pronghorn antelope (*Antilocapra americana*) may be found near the project site and is also hunted, though it is much less prevalent in the area than deer. These large mammals' use of the project site is expected to be infrequent due to the lack of shelter and water. As such, impacts to economically important species from construction are SMALL.

As described in Subsection 19.3.5.7.2.2, the project site is located in the Central Flyway corridor, centered approximately 300 mi. (483 km) east of the project site. Waterfowl and shorebirds may utilize playa lakes and human-made ponds near the project site but are not expected to stop over in the project site due to the lack of surface water features. Eden plans to consult with NMDGF on the design and use of BMPs to minimize impacts on migrating bird species. To minimize impact to migratory bird species, ground disturbance and vegetation removal is conducted outside of the primary breeding season for migratory songbirds (1 March – 1 September), when feasible. If construction must occur during the breeding season, the area

would be surveyed for active nest sites and avoidance buffers would be established, as needed (Appendix 19A).

Birds crossing through the project site may collide with tall equipment, such as construction cranes, and transmission lines during construction. If artificial lighting is used to support nighttime construction, collisions may be exacerbated (especially during migration) as research shows that birds are attracted to artificial lights during migration (Gauthreaux and Belser, 2006). However, the findings of NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Revision 2, conclude that bird collisions with cooling towers, other nuclear power plant structures, and transmission lines occur at rates that are unlikely to affect local or migratory bird populations. Eden plans to consult with the electric utility responsible for construction of the new substation and to address NMDGF and Edison Electric Institute guidance for the protection of birds. Eden is considering down-shielding of lighting, which mitigates impacts on birds and other species affected by artificial lighting. Therefore, the impacts of collisions and effects from artificial lighting on species during the construction phase are SMALL.

Due to the absence of surface water features, amphibian species are not expected to occur on the project site. A variety of birds and reptile species have the potential to occur within or near the project site and may be displaced due to construction. However, mitigation measures, such as minimizing the number of open trenches at any given time and inspecting trenches that are left open overnight to remove animals prior to backfilling, would minimize impacts on these species from construction. Overall, impacts from construction on terrestrial communities are SMALL.

19.4.5.1.4 Invasive Species

Surveys for invasive species at nearby sites have found weedy native species and exotic forb species, as described in Subsection 19.3.5.8. Surveys have not been conducted for noxious or invasive species within the EIPC site. Surveys at nearby sites in similar habitat indicate a low risk. Disturbance associated with construction activities, such as earthmoving and excavation, however, can create conditions for opportunistic invasive species to become established. Native low-water consumption vegetation is used for restoration of temporarily affected areas, which minimizes invasion by undesirable nonnative species. In accordance with NMDGF recommendations, weed-free seed is used to avoid inadvertently introducing non-native species to the site (Appendix 19A). Invasive species impacts from construction are considered SMALL and monitoring or maintenance plans are not anticipated at this time.

19.4.5.1.5 Protected Species

Consultations with the USFWS, NMDGF, and TPWD are used to obtain agency input regarding threatened and endangered species, sensitive habitats, and other ecological characteristics for the site and near-site areas. Consultation letters from USFWS, NMDGF, and TPWD were received (Appendix 19A), and information from those letters is incorporated into the Environmental Report. A list of 11 state- and federal-protected species whose known or suspected ranges are within 5 mi. (8 km) of the project site is presented in Table 19.3.5-8. Of these identified species, only the Texas horned lizard (*Phrynosoma cornutum*), northern aplomado falcon (*Falco femoralis*), and Baird's sparrow (*Centronyx bairdii*) have the potential to occur within the project site, based on habitat requirements. As discussed in Subsection 19.3.5.11, Baird's sparrows in New Mexico are winter residents only, so nesting impacts on this species are not anticipated (NMDGF, 2022c).

The northern aplomado falcon requires scattered trees, relatively low ground cover, an abundance of prey, and a supply of nest sites for essential habitat requirements. These falcons nest in abandoned stick platforms of other raptors, and nest site disturbance is a threat to the species (USFWS, 2022a). While they may use the EIPC site for foraging, the lack of trees makes it unlikely that the northern aplomado falcon would nest on the site. Thus, construction impacts on the species would be limited to removal of a small amount of foraging habitat.

The Texas horned lizard lives in open habitats with sparse vegetation and soils varying in texture from sandy to rocky. Sparse vegetation can include grass, cactus, prairie, scrubby trees, or scattered brush (TPWD, 2023). Because most of the project site is scrub/shrub habitat (see Subsection 19.3.5.2), Texas horned lizards have the potential to burrow into the soil for shelter on-site or travel through the project site. Construction impacts, however, would be limited to disturbance within the site and off-site utility corridor in New Mexico. Construction impacts are not anticipated in Texas, where the lizard is listed.

As stated in Subsection 19.3.5.11, no critical habitat for any endangered species is present within or near the project site (USFWS, 2022b), and no federal- or state-listed plants are found within Lea County (NMRPTC, 1999). One state-listed plant, dune umbrella-sedge (*Cyperus onerosus)* is found within Andrews County (TPWD, 2023), but suitable habitat does not exist on the project site (Table 19.3.5-8). Based on these findings, construction-related impacts to protected species on the EIPC site or in near-off-site areas are SMALL.

19.4.5.2 Impacts from Operations

This subsection describes the potential impacts of operation of the EIPC site on terrestrial and aquatic ecosystems.

19.4.5.2.1 Places and Entities of Special Interest

As described in Subsection 19.3.5.4, no known places or entities of special interest, including wetlands, exist on the project site (NMDGF, 2022a). Places of special interest off-site include National Public Lands, New Mexico State Trust Land, and areas with high rankings of crucial habitat as determined by the Western Association of Fish and Wildlife Agencies (USGS GAP, 2022; State Wildlife Agencies of the Western United States, 2022). These lands are not expected to be impacted by operations of the EIPC.

In summary, impacts to places and entities of special interest from operations are SMALL because such ecological resources are not present on-site and because the identified off-site resources are not impacted by operation of the EIPC site.

19.4.5.2.2 Aquatic Communities and Wetlands

As described in Subsection 19.3.5.5, no permanent surface water features are present within or near the project site. Surface water resources near the project site are depicted in Figure 19.3.4-2. None of the surface water features within the 5-mi. (8-km) region support aquatic communities. Further, Subsection 19.3.5.6 reports that wetlands are not present within the project site and only 31.2 ac. (12.6 ha) of emergent wetlands and 95.7 ac. (38.7 ha) of scrub/shrub wetlands (Figure 19.3.4-2) exist within the project region. As described in Subsection 19.2.6.1.1, blowdown from the cooling tower is routed to an approximately 13-ac-ft (16,040-m^3) evaporation pond. The evaporation pond is sized to ensure all the influent is evaporated in a timely manner for the facility to function continuously. As such, the evaporation

pond is not suitable to support aquatic communities. In addition, all stormwater collected during operations is treated as described in Subsection 19.2.2.4.3.2. Because no aquatic communities are present in the project region, and no wetlands are present within the EIPC site, impacts from operations on aquatic communities and wetlands are SMALL.

19.4.5.2.3 Terrestrial Communities

Terrestrial plant communities are characterized in Subsection 19.3.5.7.1 for the EIPC site and areas in proximity of the EIPC site. Terrestrial communities in proximity to the site consist of scrub/shrub and prairie habitat. Two rare plants, Greene milkweed (*Asclepias uncialis*) and sticky tansy-aster (*Xanthisma viscidum*), exist within the county, but historical grazing makes it unlikely that Greene milkweed is present within the project site. Although there is potential habitat for sticky tansy-aster within the EIPC site, the species is not documented in surveys at facilities in the surrounding area. As stated in Subsection 19.3.5.11, no state- or federal-listed plants are found within Lea County (NMRPTC, 1999). Operational impacts to plant communities are thus SMALL.

Wildlife communities within the EIPC site and near-site areas are described in Subsection 19.3.5.7.2. Wildlife use and occurrence on the EIPC site is expected to be low due to the history of disturbance and lack of surface water features. Unused open areas on-site are left undisturbed during operation of the EIPC for the benefit of wildlife. Operational impacts to wildlife are thus SMALL.

Birds crossing through the project site may collide with tall buildings and transmission lines during EIPC operations. As described in Section 19.4.1, the bounding height of the EIPC is approximately 42 ft. (13 m). Due to the lack of tall structures, the EIPC is not expected to result in significant mortality from bird collisions, although infrequent bird collisions resulting in mortality may occur. Nighttime security lighting may also have the potential to disorient birds and cause collisions with structures, especially during migration (Gauthreaux and Belser, 2006). However, the findings of NUREG-1437 conclude that bird collisions with cooling towers, other nuclear power plant structures, and transmission lines occur at rates that are unlikely to affect local or migratory bird populations. Further, Eden is considering down-shielding of lighting, which mitigates impacts on birds and other species affected by artificial lighting. Operational impacts to bird species and populations from collisions are therefore SMALL.

As described in Subsection 19.4.2.2.4, impacts to wildlife species from noise during all phases of the project are expected to be SMALL because exposure levels protecting humans also protect animals and because wildlife are generally already habituated to noise levels associated with adjacent industrial land uses.

19.4.5.2.4 Invasive Species

As described in Subsection 19.3.5.8, surveys have not been conducted for noxious or invasive species within the EIPC project site, but surveys for invasive species at nearby sites have found weedy native species and some exotic forb species. Nearby surveys in similar habitat, however, indicate a low risk for invasive species at the EIPC site. Eden may use herbicides in limited amounts to control unwanted vegetation during operation of the EIPC. Pest management and weed control are implemented if the presence of pest or weed intrusion is significant. Thus, operational impacts associated with invasive species are SMALL.

19.4.5.2.5 Protected Species

A list of 11 state- and federal-protected species whose known or suspected ranges are within 5 mi. (8 km) of the project site are listed in Table 19.3.5-8. Of these species, only the Texas horned lizard, northern aplomado falcon, and Baird's sparrow have the potential to occur within the project site, based on habitat requirements. In accordance with Subsection 19.3.5.11, Baird's sparrows occur in New Mexico only during the winter, thus potential impacts during operation of the EIPC are limited to foraging habitat and do not include nesting. As discussed in Subsection 19.4.5.1.5, use of the EIPC by northern aplomado falcons would also be limited to foraging and would not include nesting habitat. Due to the absence of tall structures, operation of the EIPC would not be expected to result in significant mortality to these species from collisions, although infrequent bird collisions resulting in mortality may occur. As described in Subsection 19.4.5.2.3, Eden is considering down-shielding to mitigate potential disorientation of birds that may be associated with nighttime security lighting.

As discussed in Subsection 19.4.5.1.5, habitat within the EIPC site is potentially suitable for use by Texas horned lizards. However, there are no impacts anticipated in Texas where the lizard is listed. As stated in Subsection 19.3.5.11, no state- or federal-listed plant species occur within Lea County, NM (NMRPTC, 1999). Additionally, Subsection 19.4.5.1.5 states that suitable habitat does not exist within the EIPC site for the one state listed plant (dune umbrella-sedge) cited within Andrews County, TX (TPWD, 2023; Table 19.3.5-8). The EIPC site and region do not include mapped critical habitat for any listed endangered species (USFWS, 2022b). Therefore, impacts to protected species resulting from operation of the EIPC site are SMALL.

19.4.5.3 Monitoring

Ecological monitoring, with the goal of evaluating and minimizing risk to wildlife during construction and plant operations, is currently being evaluated. As such, monitoring plans for the EIPC site have not yet been developed. If needed, appropriate agencies, such as the USFWS and NMDGF, would be consulted and agency recommendations, including monitoring elements and reporting levels, would be considered for the development of site-specific monitoring plans.

19.4.5.4 Decommissioning

Following the cessation of EIPC operations, the facility is decommissioned. Decommissioning activities, however, are similar to construction activities, and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, impacts from decommissioning are anticipated to be similar to the impacts associated with construction and are SMALL.

Table 19.4.5-1
Effects on SWReGAP Land Cover within the Project Area

	EIPC Project Area (Permanent Disturbance)		EIPC Project Area (Temporary Disturbance)	
SWReGAP Land Cover Class	**Acres**	**Percent**	**Acres**	**Percent**
Apacherian-Chihuahuan Mesquite Upland Scrub	42.9	77.1	29.4	78.3
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	0.8	1.5	0.1	0.2
Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	6.0	10.8	4.2	11.3
Chihuahuan Mixed Salt Desert Scrub	5.0	8.9	3.2	8.4
Western Great Plains Sandhill Shrubland	1.0	1.7	0.6	1.7
Total	**55.7**	**100.0**	**37.5**	**100.0**

Source: Lowry et al., 2005
a) Total may be more or less than 100 percent due to rounding.
Abbreviations: EIPC = Eden Isotope Production Complex | SWReGAP = Southwest Regional Gap Analysis Project

19.4.6 HISTORIC AND CULTURAL RESOURCES

19.4.6.1 Impacts to Historic Properties

As described in Section 19.3.6, no historic properties or archaeological sites are located within or immediately adjacent to the EIPC project site. A cultural resource survey (Appendix 19B) identified six isolated occurrences of archaeological and historic resources. All the occurrences were determined ineligible for inclusion on the National Register of Historic Places (NRHP) (NPS, 2022) and no further work was recommended. Therefore, no direct impacts are anticipated within the direct area of potential effect (APE). If, however, any sites are identified in the future, the sites would either be recorded and avoided, or other proper steps would be taken to preserve the site for future excavation and study.

As described in Subsection 19.3.6.2, the extent of the visual APE (i.e., the indirect APE) is a 0.3-mi. (0.5-km) radius extending from the proposed project boundary. The State Register of Cultural Properties (SRCP) (NMHPD, 2022) and the NRHP list no properties within the indirect APE. Therefore, given the low profile of the proposed structures and that no listed property occurs within the project area or a 0.3-mi. (0.5-km) radius, the proposed project does not result in visual or other indirect impacts to historic properties.

As described in Subsection 19.3.6.2, the northern portion of the off-site utility corridor, north of NM-176 (Figure 19.3.1-1), has been previously surveyed for cultural resources (Proper, 2007) and none were identified. Utilities for the project site are sited within the previously surveyed section of the off-site utility corridor. If utilities cannot be limited to the previously surveyed section of the off-site corridor, a cultural resource survey of the proposed new utility corridor would be performed before any ground disturbances are conducted.

Based on the absence of historic properties or archaeological sites on the EIPC project site and the absence of SRCP- and NRHP-listed properties near the EIPC project site, the potential impacts to historic and archaeological resources from construction, operations, and decommissioning are SMALL.

19.4.6.2 Consultation

The New Mexico Historic Preservation Division (NMHPD) reviewed the findings of the archaeological survey on October 14, 2022, and expressed no concerns regarding the findings of the archaeological investigation and has no other comments or information to provide for the proposed facility (Appendix 19A). Due to the facility being licensed by the NRC, the NRC must consult with the State Historic Preservation Officer (SHPO) and NMHPD and request concurrence with the effect determination based on the cultural resource survey and the results of their consultation with Native American Tribes.

Additionally, consultation was initiated on September 30, 2022, with federally recognized Native American tribes that have an interest in the EIPC project site (see Appendix 19A). Consultation letters were sent to the Apache Tribe of Oklahoma, Comanche Nation of Oklahoma, Kiowa Tribe of Oklahoma, Lipan Apache Tribe, Mescalero Apache Tribe, Texas Band of Yaqui Indians, Tonkawa Tribe of Oklahoma, Wichita and Affiliated Tribes, and Ysleta del Sur Pueblo. Follow-up emails were sent to the tribes, however at this time no responses have been received.

19.4.6.3 Potential for Human Remains

There is low potential for human remains to be present on the EIPC project site and off-site utility corridor. Should unexpected discovery of such remains be made before or during construction, EIPC staff would halt construction activities immediately in the area of discovery and notify the representatives of the Lea County Medical & Coroner and the New Mexico SHPO. The Lea County Medical & Coroner and the SHPO would determine the appropriate measures to identify, evaluate, and treat these discoveries. If the remains are potentially Native American, EIPC staff would, in addition to the above actions, contact the federal agency that has primary management authority as well as appropriate Native American tribes, if known or readily ascertainable. EIPC staff would also set forth efforts to protect the items discovered before resuming construction activities in the vicinity of the discovery. Construction activities would resume only after the appropriate consultations and notifications have occurred and guidance has been received.

19.4.6.4 Mitigation Measures

Mitigation plans are developed, as appropriate, in conjunction with National Historic Preservation Act Section 106 consultation conducted by the NRC, the New Mexico SHPO, the State Land Office, Lea County, the Advisory Council on Historic Preservation, and affected Native American tribes for any unanticipated discoveries to minimize adverse impacts.

19.4.7 SOCIOECONOMICS

19.4.7.1 Socioeconomic Impacts

This subsection describes the potential socioeconomic impacts from construction, operation, and decommissioning of the project on population and housing, employment and economic activity, and public services and finances within the three-county region of influence (ROI), identified in Section 19.3.7 as Lea County, NM, Andrews County, TX, and Gaines County, TX.

19.4.7.1.1 Population Impacts

As described in Subsection 19.2.1.3 and Subsection 19.2.1.5, the workforce needed for construction, operation, and decommissioning of the EIPC and the duration of each phase are listed below:

a. Construction:
   - Workforce: 26 – 233, depending on phase.
   - Anticipated duration: 3 years.
b. Operations:
   - Workforce: 119 – 146 with an average operations workforce of 132.
   - Anticipated duration: 40 years.
c. Decommissioning:
   - Workforce: up to 71, depending on phase.
   - Anticipated duration: 2 years.

As the eventual decommissioning phase begins in the far future, decommissioning impacts are listed separately in Subsection 19.4.7.1.6 and Subsection 19.4.7.2.3.3.

A portion of the needed workforce is assumed to move into the ROI for the duration of each respective phase. Estimates regarding workforce characteristics are developed using assumptions documented by the NRC in a previous licensing action for a facility in Lea County, NM (NUREG-2237, Environmental Impact Statement for the Holtec International's License Application for a Consolidated Interim Storage Facility for Spent Nuclear Fuel in Lea County, New Mexico). These assumptions are provided in Table 19.4.7-1. Assumptions regarding the percentage of the construction and operations workforce that relocate to the ROI are made in conjunction with methodology used by the NRC in previous environmental studies (see Table 19.4.7-1). These assumptions are consistent with workforce assumptions for other NRC licensing actions in the eastern New Mexico area (NRC, 2015; NUREG-2237).

It is estimated that between approximately 26 and 233 workers are needed, depending on the phase, for construction of the EIPC. As shown in Table 19.4.7-1, approximately 10 to 30 percent of the construction staff may need to migrate into the ROI. Assuming the most conservative scenario of 30 percent in-migration, approximately 70 of the 233 construction workers are drawn from outside the ROI. Of the 119 – 146 operations workers, with an average workforce of 132, approximately 40 to 60 percent are needed from outside the ROI (see Table 19.4.7-1). Assuming the most conservative scenario of 60 percent in-migration of the average operations

workforce, approximately 79 workers migrate into the ROI during the operations phase (see Table 19.4.7-1).

Table 19.4.7-2 details the distribution of in-migrating construction and operations workers throughout the ROI. Assuming that the workforce is distributed across the ROI in proportion to county population size, approximately 64.9 percent migrate into Lea County, NM, approximately 16.2 percent migrate into Andrews County, TX, and approximately 18.8 percent migrate into Gaines County, TX, during both the construction and operations phases. It is also assumed that each worker that migrates into the ROI does so accompanied by family members. The average household size in the United States is approximately 2.51 (USCB, 2021). Therefore, an in-migrating construction workforce of 70 increases the ROI population by 175 people. The addition of 70 construction workers and their families results in an approximately 0.15 percent increase to the total population within the ROI. The in-migrating average operations workforce of 79 increases the ROI population by 199 people. The addition of 79 operations workers and their families results in an approximately 0.17 percent increase to the total population within the ROI. Because the in-migrating workforce increases the population within the ROI by less than 0.2 percent, impacts to population from the in-migrating construction and operations workforces are SMALL.

The precise distribution of workers migrating into the ROI is determined by several factors, including proximity to the project area, housing, and available public services. The exact distribution of the in-migrating workers within the ROI is unknown. The maximum impact of the EIPC on population for each county can be evaluated by assuming that all of the in-migrating operations workers and their families move into one county within the ROI. The in-migrating population for the operations phase is selected because it is larger than the in-migrating population during the construction phase. The associated population increase for each county based on the 2020 population data is approximately 0.3 percent in Lea County, NM, 1.1 percent in Andrews County, TX, and 0.9 percent in Gaines County, TX. Therefore, even if all of the in-migrating workforce population moves into one county within the ROI, the impacts to population from construction and operation of the EIPC remain SMALL.

19.4.7.1.2 Housing Impacts

Housing characteristics in the ROI are described in Subsection 19.3.7.2.3 and in Table 19.3.7-6. These data are used as the basis for estimating the number of housing units that may be available to accommodate housing demand from the in-migrating construction and operations workforce and their families. As detailed in Subsection 19.3.7.2.3, there are 5328 vacant units within the ROI. Table 19.4.7-3 details the utilization of available housing by in-migrating construction and operations workers and their families. The households of the in-migrating construction workforce occupy approximately 1.3 percent of the 5328 total available vacant housing units in the ROI. The percentage of vacant units occupied by the in-migrating construction workforce ranges from 1.1 percent in Lea County, NM, to 2.1 percent in Gaines County, TX. Households of the in-migrating operational workforce occupy approximately 1.5 percent of the total vacant housing units in the ROI, ranging from 1.3 percent in Lea County, NM, to 2.4 percent in Gaines County, TX. Therefore, adequate housing is likely available to the construction and operational workforce and their families. The potential impact to housing due to the in-migrating workforce during construction and operations is SMALL.

As stated in Subsection 19.4.7.1.1, the exact geographic distribution of in-migrating construction and operations workers is unknown at this time. As a conservative measure, if it is assumed that all in-migrating operations workers and their families move into one county within the ROI, the

maximum impact to housing can be estimated. The associated utilization of vacant housing is 2.0 percent in Lea County, NM, 11.3 percent in Andrews County, TX, and 12.6 percent in Gaines County, TX. As employment during the operations phase is larger than during construction, the magnitude of the impact on housing is bounded under the operations phase. As a result, under this conservative scenario, the impact on housing due to in-migrating construction and operations workforces remains SMALL.

19.4.7.1.3 Public Services Impacts

Community facilities, which include recreation, healthcare, water and wastewater systems, and public safety services and facilities, are described in Subsection 19.3.7.2.5. The in-migrating construction and operations workforces impact access and demand for these facilities and services. As detailed in Table 19.4.7-2, the population within the ROI is anticipated to increase by less than 0.2 percent during both the construction and operations phases. As such, impacts to recreation facilities and public safety services are SMALL. Additionally, if all in-migrating construction and operations workers and their families move into one county within the ROI, the associated population increase ranges from 0.3 to 1.1 percent. Therefore, impacts to these facilities are SMALL given this minor increase in population under this scenario.

Construction and operation of the EIPC require potable water use. As noted in Section 19.2.5, water for both potable and industrial use is obtained from the Eunice municipal water supply. Subsection 19.2.2.4 details infrastructure improvement involving the use of potable water. The exact amount of water used during construction is not verified, but is anticipated to be less, and therefore, bounded by the operational water usage of 20.2 MGPY (76.5 MLPY). As described in Subsection 19.3.7.2.5.1, Eunice has access to approximately 3292 ac-ft/year (406 ha-m/year) or 1072 MGPY of water.

It is also anticipated that the EIPC creates 4.5 MGPY (17.0 MLPY) of industrial wastewater and 5.7 MGPY (21.6 MLPY) of sanitary wastewater. As described in Subsection 19.2.2.4.3.2, sanitary wastewater is treated by the City of Eunice’s wastewater treatment plants. As described in Subsection 19.2.6.1.1, blowdown from cooling towers and LECS is routed to the evaporation pond. Therefore, impacts to water during construction, operations, and decommissioning are anticipated to be SMALL.

19.4.7.1.4 Public Education Impacts

Available schools and student enrollment numbers are discussed in Subsection 19.3.7.2.4 and identified in Table 19.3.7-8. As noted in Subsection 19.3.7.2.4, there are 59 schools within the ROI. A majority of those schools are located in Lea County, NM, within which there are 42 schools. Legislation passed in New Mexico and Texas limits the student-to-teacher ratios; the most stringent is 20 to 1 in New Mexico and 22 to 1 in Texas (FindLaw, 2021; Texas Education Agency, 2022). As described in Table 19.4.7-4, student-to-teacher ratios within the ROI range from 14.4 to 21.5, with an overall ratio of 17.0 in the ROI. Assuming conservatively that all in-migrating families, outside of the in-migrating workers, are made up of school-aged children, approximately 106 school-aged children move into the ROI as a result of the in-migrating construction workforce, and approximately 120 school-aged children move into the ROI as a result of the in-migrating operations workforce. The respective increases in student enrollment increase the student-to-teacher ratio in Lea County, NM, from 16.8 to 16.9 and in Gaines County, TX, from 21.5 to 21.6, while the Andrews County, Texas student-to-teacher ratio remains at approximately 14.4. The new overall ROI ratio increases from 17.0 to 17.1 during both the construction and operations phases. Because the potential number of incoming

school-aged children during both phases is minimal and the increases in student-to-teacher ratio are approximately 0.1, impacts to public education are SMALL.

The most conservative impact to education can be estimated if it is assumed that all in-migrating construction and operations workers and their families move into one county within the ROI. The construction-phase impacts can be bounded by the operations phase as the impacts are smaller. Therefore, assuming that all in-migrating persons during the operations phase move into one county and all families consist of one worker and school-aged children, the student-to-teacher ratio increases from 16.8 to 17.0 in Lea County, NM, from 14.4 to 14.8 in Andrews County, TX, and from 21.5 to 22.1 in Gaines County, TX. As the related increase in student-to-teacher ratios is less than 1, the impact to education remains SMALL under this scenario.

19.4.7.1.5 Tax Revenue-Related Impacts

Estimated tax revenues during construction and operation of the EIPC are generated via the following taxes:

- Local, including real estate and sales taxes.
- State, including personal income taxes and the New Mexico Gross Receipts Tax.
- Federal, through personal income taxes.

19.4.7.1.5.1 Personal and Corporate Income Taxes

Using U.S. Bureau of Labor Statistics (BLS) data for construction laborers in New Mexico (BLS, 2021), Eden estimates that each year of construction generates a total increase in income from direct jobs of about $4.5 million and approximately $472,500 in combined personal income tax and New Mexico Gross Receipts Tax. Federally, a total increase in income from direct jobs of about $4.5 million generates approximately $675,000 in personal income tax revenue based on a nominal 15 percent effective tax rate. Eden estimates that during the operations period, workers occupy a variety of engineering positions. Using BLS data for mean annual salary for engineering operations staff in New Mexico (BLS, 2021), Eden estimates annual operational activities generate a total increase in income from direct jobs of approximately $12 million and approximately $1.2 million in combined personal income tax and New Mexico Gross Receipts Tax. Federally, a total increase in income from direct jobs of about $12 million generates approximately $1.8 million in personal income tax revenue based on a nominal 15 percent effective tax rate. The State of New Mexico reported approximately $101.6 million in personal state income for the fiscal year 2021 (State of New Mexico, 2021); the estimated EIPC personal income generated accounts for less than 0.1 percent of the 2021 state personal income. Impacts to personal and corporate income taxes from salary payments during the life of the EIPC are SMALL and beneficial to the ROI.

19.4.7.1.5.2 Sales Taxes

During the construction and operations phases of the EIPC, workers generate sales taxes through worker expenditures and facility spending on materials and supplies. Retail expenditures generate sales and use taxes within the ROI, as workers spend some of their income on goods and services that may be taxed. The purchase of construction materials and supplies for the EIPC also generates sales taxes. Projected retail expenditures and expenditures for construction materials and supplies purchased during construction are not available. However, Eden estimates that the construction workforce generates an annual

income of approximately $4.5 million, and operations jobs generate an annual income of $12 million. Increased income results in additional expenditure on goods and services, which are subject to sales taxes throughout the ROI. Therefore, the potential impacts to taxes within the ROI are SMALL and beneficial.

19.4.7.1.5.3 Property Taxes

Property tax paid for the undeveloped EIPC in 2021 was $5485 and remained the same in 2022. Future property taxes on the EIPC are determined based on the assessed value of the property. At this time, that value cannot be determined, but is anticipated to be greater as the land is currently undeveloped.

Construction, operations, and decommissioning workers who live within the ROI continue to pay existing property tax. The in-migrating construction and operations workers also contribute to local and state property tax revenue. Impacts to property taxes within the ROI are SMALL and beneficial.

19.4.7.1.6 Decommissioning

The composition of the workforce needed for decommissioning the EIPC is similar, but, as noted in Subsection 19.4.7.1.1, is smaller than the workforce needed during the construction and operations phases. Therefore, decommissioning has similar but smaller impacts than the construction and operations phases. Thus, impacts to socioeconomics during decommissioning are anticipated to be SMALL.

19.4.7.1.7 Mitigation Measures to Minimize Socioeconomic Impacts

Socioeconomic impacts to the ROI resulting from construction, operations, and eventual decommissioning of the EIPC are SMALL and mostly beneficial. Therefore, no mitigation measures are required to minimize impacts.

19.4.7.2 Transportation

This subsection provides construction- and operations-related effects on the transportation network. The effects on the local transportation infrastructure as a result of construction and operations are measured against the current conditions described in Subsection 19.3.7.2.5.4 and future (2032) no-build traffic conditions provided in Table 19.4.7-5.

19.4.7.2.1 Construction/Modification of Transportation Infrastructure

The EIPC is accessed via one driveway that extends north from the facility to NM-176, as shown on Figure 19.2.1-4. Eastbound and westbound deceleration lanes are necessary on NM-176 to allow for right and left turns into the new EIPC access driveway, respectively, which requires widening a short segment of NM-176 (Bohannan, 2020).

There are no pedestrian facilities along NM-176 due to the relatively high speeds of vehicles along NM-176 and the rural nature of the area. There are currently no bicycle designations along NM-176; therefore, no additional bicycle facilities are necessary. No other additions or modifications to transportation infrastructure are anticipated in association with the EIPC site.

As construction and operation of the EIPC require only minor modifications to existing transportation infrastructure, including the addition of an access driveway and widening of a segment of NM-176 to allow for deceleration lanes, impacts to transportation infrastructure are SMALL.

19.4.7.2.2 Transportation Routes for Conveying Materials and Personnel to the Project Site

Existing roadway networks are utilized to convey construction equipment, non-radiological materials, and/or personnel to the EIPC site via NM-176. Transportation of nuclear materials is discussed in detail in Section 19.4.10.

19.4.7.2.3 Traffic Pattern Impacts

This subsection discusses impacts to traffic patterns from the EIPC.

19.4.7.2.3.1 Impacts of Construction

Increased traffic associated with the construction workforce traveling to and from the EIPC, as well as the mobilization of heavy equipment, generates an associated increase in traffic on the local roadway network. As noted in Subsection 19.2.1.5, the estimated number of workers during the construction phase ranges from 26 to 233. The daily commuting workforce plus intermittent equipment mobilization to and from the project site increases traffic relative to current background levels, with the most notable increases associated with the start and stop of daytime shift work when traffic volumes are highest. As discussed in Subsection 19.3.7.2.5.4, existing annual average (2019) daily traffic volumes on NM-176 consist of 4801 vehicles and 1311 trucks. Thus, the increase in traffic associated with the construction workforce and intermittent equipment mobilization is minimal compared with existing traffic flow. In addition, notable increases in traffic are limited to NM-176 near the EIPC access driveway. At further distances, construction-related vehicles disperse into the local transportation network and integrate into typical traffic patterns. Therefore, impacts to the transportation system associated with construction of the EIPC are temporary and SMALL.

19.4.7.2.3.2 Impacts of Operations

A traffic analysis was performed to assess the post-development operations-related traffic conditions at the EIPC site (Bohannan, 2020). Five unsignalized intersections along NM-176, shown in Figure 19.4.7-1, were analyzed in detail, including the EIPC access driveway intersection. The analysis assumed that an eastbound right turn deceleration lane and a westbound left turn deceleration lane are present on NM-176 at the EIPC driveway intersection.

It is conservatively estimated that 780 vehicles visit the project site daily during operations, resulting in a two-way volume of 1560 additional trips per day (Bohannan, 2020). A summary of the effect of operations-related traffic volumes on the surrounding roadway network (in future year 2032) is provided in Table 19.4.7-5. Operation of the facility results in a slight degradation in the level of service (LOS) (from LOS B [reasonably free flow conditions with maneuverability slightly restricted by the presence of other vehicles] to LOS C [stable flow, at or near free flow conditions but with maneuverability noticeably restricted by increased traffic density]) at the intersection of NM-176 and NM-18 during the morning peak hour, resulting in an increased delay at the intersection of approximately 3.5 seconds (sec.). Additionally, the new intersection at NM-176 and the EIPC access driveway operates at LOS C during morning and afternoon peak hours, compared with LOS A (free flow with complete mobility) under the no-build

scenario. All the LOS levels were determined to be acceptable (LOS C or better) for the overall intersections and individual movements within the intersections for the future year (2032) conditions and meet the requirements of the NMDOT's minimum acceptable LOS standards. Therefore, traffic conditions during operations are not significantly degraded and transportation impacts are SMALL.

19.4.7.2.3.3 Impacts of Decommissioning

At the end of the license term for the EIPC site, the facility is decommissioned, which involves dismantling the EIPC and disposal of radioactive or contaminated equipment and materials to levels that satisfy regulatory release regulations. As noted in Subsections 19.2.1.4.3 and 19.2.1.5, decommissioning activities involve heavy equipment similar to that used during the construction phase and requires a smaller workforce, peaking at approximately 71 full-time workers. Therefore, transportation-related impacts of project-related traffic during decommissioning are expected to be similar to or less than those impacts described for the construction phase. Therefore, impacts during the decommissioning period are SMALL.

19.4.7.2.4 Mitigation Measures to Minimize Transportation Impacts

As impacts to transportation associated with the construction, operations, and decommissioning of the EIPC are SMALL and traffic patterns adhere to the requirements of NMDOT's minimum acceptable LOS standards, no mitigation measures are necessary.

Table 19.4.7-1
Assumptions for Workforce during Construction and Operations Stages

Workforce Characterization during Construction and Operations	Value
Construction	
Percentage of construction workers who may move into the ROI	10% – 30%
Range in number of construction workers who may move into the ROI	23 – 70
U.S. average family size	2.51
Range of total number of construction workers and family members moving into the ROI	58 – 175
Operations	
Percentage of operations workers who may move into the ROI	40% – 60%
Range in number of operations workers who may move into the ROI	53 – 79
U.S. average family size	2.51
Range of total number of operations workers and family members moving into the ROI	133 – 199

Source: NUREG-2237; USCB, 2021
Abbreviations: ROI = Region of Influence | U.S. = United States

Table 19.4.7-2
Estimated Population Increases in the Region of Influence

Geography	In-Migrating Workforce	Total In-Migrating Persons	2020 Population	Percent of ROI (2020 Population)	Percent Increase from Total In-Migrating Persons (2020)	Estimated 2030 Population	Percent Increase from Total In-Migrating Persons (2030)
Construction							
Lea County, NM	45	114	74,455	64.9	0.15	80,093	0.14
Andrews County, TX	11	28	18,610	16.2	0.15	35,751	0.08
Gaines County, TX	13	33	21,598	18.8	0.15	27,881	0.12
ROI Total	**70**	**175**	**114,663**	**100**	**0.15**	**143,725**	**0.12**
Operations							
Lea County, NM	51	129	74,455	64.9	0.17	80,093	0.16
Andrews County, TX	13	32	18,610	16.2	0.17	35,751	0.09
Gaines County, TX	15	37	21,598	18.8	0.17	27,881	0.13
ROI Total	**79**	**199**	**114,663**	**100**	**0.17**	**143,725**	**0.14**

Source: University of New Mexico, 2022; Texas Demographics, 2022
Note: Estimates are rounded to the nearest whole number, accounting for discrepancies between the ROI total and the sum of the three ROI counties.
Abbreviations: ROI = region of influence | NM = New Mexico | TX = Texas

Table 19.4.7-3
Housing Availability and Usage in the Region of Influence

	Lea County, NM	Andrews County, TX	Gaines County, TX	ROI[(a)]
Available Housing				
Total Housing Units	26,871	6347	6505	39,723
Vacant Housing Units	4003	698	627	5328
Phase				
In-Migrating Construction Workforce	45	11	13	70
Vacant Housing Unit Rate of Occupation by Construction Workforce	1.1%	1.6%	2.1%	1.3%
In-Migrating Operations Workforce	51	13	15	79
Vacant Housing Unit Rate of Occupation by Operations Workforce	1.3%	1.8%	2.4%	1.5%

Source: USCB, 2020a (Housing Characteristics)

a) Estimates are rounded to the nearest whole number, accounting for discrepancies between the ROI total and the sum of the three ROI counties.
Abbreviations: NM = New Mexico | TX = Texas | ROI = Region of Influence

Table 19.4.7-4
School Enrollment in the Region of Influence during Construction and Operations Phases

Geography	Total Number of Schools	Student Enrollment[a]	Teachers (FTEs)[b]	Student-to-Teacher Ratio	Construction-Related Increase in Enrollments	Related Increase in Student-to-Teacher Ratio	Operations-Related Increase in Enrollments	Related Increase in Student-to-Teacher Ratio
Lea County, NM	42	15,112	897.4	16.8	69	16.9	78	16.9
Andrews County, TX	6	4128	287.2	14.4	17	14.4	19	14.4
Gaines County, TX	11	4189	194.9	21.5	20	21.6	23	21.6
ROI Totals	**59**	**23,429**	**1379.5**	**17.0**	**106**	**17.1**	**120**	**17.1**

Source: NCES, 2022
a) Estimates are rounded to the nearest whole number, accounting for discrepancies between the ROI total and the sum of the three ROI counties.
b) FTE = Full-time equivalent employee (part-time workers are reported as a fraction of one full-time worker).
Abbreviations: FTE = full time equivalent | NM = New Mexico | TX = Texas | ROI = Region of Influence

Table 19.4.7-5
NM-176 Intersection Capacity Analysis Results (2032)

Intersection Name	Case[a]	Projected Level of Service (delay in seconds)	
		AM Peak	PM Peak
NM-176/NM-18	No-Build	B (14.3)	C (16.6)
	Build	C (17.8)	C (20.1)
NM-176/EIPC Driveway	No-Build	A (0)	A (0)
	Build [a]	C (18.7)	C (23.6)
NM-176/URENCO West Driveway	No-Build	A (0)	A (0)
	Build	A (0)	A (0)
NM-176/URENCO East Driveway	No-Build	A (8.5)	A (9.8)
	Build	A (8.8)	A (9.9)
NM-176/Environmental Lane	No-Build	A (13.0)	A (0)
	Build	A (13.5)	A (0)

Reference: Bohannan, 2020
a) Build analysis assumes eastbound right-turn deceleration lane and westbound left-turn deceleration lane are present on NM-176 at the EIPC Driveway intersection.
Abbreviations: NM = New Mexico | EIPC = Eden Isotope Production Complex | URENCO = Uranium Enrichment Corporation

19.4.8 HUMAN HEALTH

19.4.8.1 Nonradiological Impacts

This subsection discusses the potential nonradiological public and occupational hazards as they pertain to construction, operation, and decommissioning of the proposed EIPC. Regulations for generating, managing, handling, storing, treating, protecting, and disposing of wastes during construction, operation, and decommissioning of the proposed EIPC are contained in federal regulations issued and overseen by the NRC and USEPA, and in New Mexico Statutes Annotated (NMSA) 1978 (NMSA, 1978). These regulations include compliance with provisions of the Clean Air Act (CAA) (42 United States Code [U.S.C.] §7401 et seq.), CWA of 1977 (33 U.S.C. §1251 et seq.), Atomic Energy Act of 1954 (42 U.S.C. §2011 et seq.), and Resource Conservation and Recovery Act (42 U.S.C. §6901 et seq.), among others. Specifically for New Mexico, the potentially applicable environmental management regulations are provided in state statutes (NMSA Chapters 4, 50, and 74).

Nonradiological hazards are associated with emissions, discharges, and waste from processes within the facility as well as accidental spills/releases. Nonradioactive wastes generated by construction, operation, and decommissioning of the EIPC, including solid wastes, liquid wastes, and air emissions, are managed in accordance with applicable federal, state, and local laws and regulations, and applicable permit requirements.

19.4.8.1.1 Nonradioactive Chemicals and Wastes and Management

19.4.8.1.1.1 Nonradioactive Chemical Sources

During construction, nonradioactive chemical sources are reasonably expected to be on-site in liquid, gaseous, and solid forms. These sources include fuels, oils, solvents, and other materials necessary for site preparation and construction. During operations, in addition to radioactive chemical sources, production processes include nonradioactive chemical sources in liquid, gaseous, and solid forms. Pollutants may be present in wastewater as well as in air emissions associated with the EIPC. Solid wastes are also generated. Consequently, the focus of the following subsections are potential impacts of sanitary wastewater, air emissions, and solid waste on human health.

The bounding inventory of major sources of chemicals (i.e., those in quantities of 1000 pounds [lb.] or 454 kilograms [kg] or more) stored and used during operations at the EIPC is provided in Table 19.4.8-1.

19.4.8.1.1.2 Nonradioactive Liquid, Gaseous, and Solid Waste Management and Control Systems

19.4.8.1.1.2.1 Liquid Wastes

As described in Section 19.2.4, some chemical use is expected to occur outside the HCF processing line. Liquid wastes produced as a result of these activities are sampled and treated, as necessary, to meet the requirements of the Eunice wastewater treatment facility before being discharged. Water that is acceptable for discharge is treated as described in Subsection 19.2.7.2. Small quantities of nonradioactive, hazardous wastes that cannot be released with the wastewater are stored in an appropriate location until they can be properly

dispositioned. Facility sanitary wastewater is designed to be conveyed via the sewer system to the Eunice wastewater treatment facility.

19.4.8.1.1.2.2 Gaseous Wastes

As described in Subsection 19.2.4.4, the EIPC generates gaseous effluents resulting from process operations and the ventilation of operating areas. The gaseous effluent sources from ventilation of operating areas include the following systems:

- RF high bay ventilation system — Where the RF exhaust airstream is treated with an appropriate filter train, including prefilter, and high-efficiency particulate air (HEPA) filter, as required to meet regulatory discharge standards prior to discharge to the atmosphere through the exhaust stack.
- HCF ventilation system — Where the HCF exhaust airstreams, including fuel target area ventilation, are treated with an appropriate filter train, including prefilter, charcoal, and HEPA filter, as required to meet regulatory discharge standards prior to discharge to the atmosphere through one of the two exhaust stacks.

All the gaseous effluents from process operations at the EIPC are vented to the atmosphere through elevated stacks; therefore, no direct or indirect exposure to gaseous effluents is anticipated to occur. Nonradiological air emissions are evaluated in Subsection 19.4.2.1. Based on the results of the evaluation, the EIPC does not cause or contribute to an exceedance of the NAAQS or NMAAQS. As a result, there are no human health impacts associated with nonradiological air emissions.

19.4.8.1.1.2.3 Solid Wastes

Representative nonradioactive solid wastes that are generated by the project during construction, operations, and decommissioning include wood from crates, packaging from receiving activities, metal shavings, wires, batteries (alkaline, lithium), expired lights and fixtures, paper, office supplies, cleaning supplies, and empty plastic containers.

Other nonradioactive solid wastes are anticipated to be generated in conjunction with routine operations. Solid waste management and control measures for the EIPC include waste reduction, recycling, and waste minimization practices that are employed during all project phases (construction, operations, decommissioning). Waste management practices implemented at the EIPC include the following:

- Disposing of solid wastes at an off-site permitted recycling or recovery facility, as appropriate.
- Minimizing hazardous wastes consistent with the waste minimization certification (40 CFR 262.27).
- Use of waste staging areas to segregate and store wastes and reduce/minimize waste volumes through a waste management program and associated procedures.
- Use of operating practices that minimize energy consumption and the generation of solid wastes, liquid wastes, liquid effluents, and gaseous effluents.
- Performing a waste assessment and developing and using a waste recycling plan for nonhazardous wastes.

- Implementing an SPCC plan.

19.4.8.1.1.3 Nonradioactive Effluents Released

A list of chemicals released as air emissions during operation to the on-site and off-site environment is provided in Section 19.4.2. This subsection provides information regarding the sources, compositions, and quantities of projected air emissions from the EIPC.

The EIPC is expected to release permitted amounts of maintenance and laboratory chemicals to the Eunice wastewater treatment facility. Administrative controls are designed to ensure that these effluents are appropriately dispositioned to meet the Eunice wastewater treatment facility requirements.

19.4.8.1.2 Nonradiological Impacts

19.4.8.1.2.1 Chemical Exposure to the Public

19.4.8.1.2.1.1 Air Emissions

Calculated chemical exposure to the public is described and discussed in Section 19.4.2 regarding air emissions from the EIPC. Potential air emission effects to the public are limited to indirect impacts as the potential receptors are located off-site. Consequently, there are no direct impacts to the public from air emissions.

Emissions are not anticipated to exceed the primary ambient air quality standards that have been established to protect public health, including the health of sensitive populations such as children, the elderly, and those with respiratory problems. Therefore, pollutant impacts to receptors within a short distance of the site that could be impacted and at points of the maximum individual exposure are SMALL.

19.4.8.1.2.1.2 Liquid Effluents

As discussed previously, the EIPC is not expected to release liquids containing chemicals to the environment exceeding the limits permitted for the evaporation pond. Industrial wastewater is discharged to the evaporation pond and sanitary wastewater is discharged to the Eunice wastewater treatment facility. Prior to release, wastewater discharged to the evaporation pond is designed to undergo treatment/sanitization commensurate with the requirements of the discharge permit issued by the NMED Ground Water Quality Bureau.

No direct or indirect impacts of liquid effluents from the EIPC are anticipated. Therefore, the impact on human health from liquid discharges is SMALL.

19.4.8.1.2.2 Physical Occupational Hazards

The exposure characteristics of the workforce for nonradiological hazards are defined when operating strategies are finalized. Because occupational hazards occur on-site and during construction, operation, and decommissioning of the EIPC, they are considered direct impacts. No indirect impacts (off-site) have been identified.

Physical hazards are addressed and managed through implementation of safety practices, training, and control measures, and, as such, impacts from physical occupational hazards are determined to be SMALL.

19.4.8.1.2.3 Chemical Exposure to the Workforce

As planned and permitted, the EIPC does not store or use highly hazardous chemicals in quantities above the Threshold Quantities in Appendix A to 29 CFR 1910.119 during construction. During operations, quantities of nitric acid above the Threshold Quantity are present on-site and, therefore, the requirements of 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals, apply to the facility at that time. The majority of process chemicals are used in liquid form and contained in tanks, barrels, bottles, pipes, and hot cells, thereby limiting workforce exposure. Because potential chemical exposures to the workforce during operation of the EIPC occur on-site, they are considered direct impacts. No indirect impacts (off-site) have been identified. EIPC design, engineering controls, and management safety practices are applied to keep air contaminants below the limits in 29 CFR 1910.1000. In summary, occupational hazards are managed and minimized by compliance with Occupational Safety and Health Administration (OSHA) regulations, and, as such, impacts from chemical occupational hazards are determined to be SMALL.

19.4.8.1.3 Environmental Monitoring Programs

Regulations for generating, managing, handling, storing, treating, protecting, and disposing of wastes during construction, operation, and decommissioning of the proposed EIPC are summarized above in Subsection 19.4.8.1.

Nonradioactive wastes generated by construction, operation, and decommissioning of the facility are managed in accordance with applicable federal, state, and local laws and regulations, and applicable permit requirements. The specific details for these activities and processes are addressed in the safety analyses.

19.4.8.1.4 Mitigation Measures

Mitigation measures are used to protect human health and are in addition to actions taken to comply with applicable environmental regulations. Eden is committed to identifying and implementing BMPs during construction, operation, and decommissioning of the EIPC to minimize pollutant releases to on-site and off-site areas, to safely deliver normal sanitary wastewater to the Eunice wastewater treatment facility, safely discharge industrial wastewater to the evaporation pond, and to provide air emission controls, as appropriate. Required permits are expected to be obtained for effluents and emissions. Furthermore, waste reduction practices are employed including recycling and waste minimization.

19.4.8.2 Radiological Impacts

This subsection describes the public and occupational health impacts from radioactive material due to normal operational activities at the EMIF.

19.4.8.2.1 Layout and Location of Radioactive Material

With the exception of the reactor start-up source and instrumentation calibration sources and fission chambers, all radiation sources in the EMIF emanate from low-enriched uranium (LEU)

irradiated in the reactor or from the neutron activation of materials irradiated near the reactor. Likewise, most radioactive waste generated in or present in the EMIF emanates from LEU irradiated in the reactor or from the neutron activation of materials irradiated near the reactor. Wastes are also generated from contaminated equipment and PPE.

The radiation sources associated with the EMIF operations primarily consist of:

- Reactor and reactor hardware.
- Reactor neutron source and calibration sources.
- Fission chambers and dosimetry foils.
- Irradiated targets (including activation).
- LEU, targets, and target materials.
- Process waste.
- Radioactive nonfuel hardware.
- Medical isotope products.
- Primary coolant or LECS demineralizer resins (if generated).
- Ventilation system filters.
- Evaporation pond.

Additional details will be provided in the Operating License Application.

19.4.8.2.2 Characteristics of Radiation Sources and Expected Radioactive Effluents

The three common sources of radiation for operating nuclear facilities (gaseous, liquid, and fixed) and the expected effluents released from the EMIF are discussed in this subsection.

Additional details about radiation sources, including activity, composition, and radiation fields will be provided in the Operating License Application.

19.4.8.2.2.1 Gaseous Sources of Radiation

Gaseous radionuclides such as argon-41 (Ar-41), tritium (H-3), and nitrogen-16 escaping from the pool water are removed from the RF high bay by the ventilation system and exhausted through the RF exhaust stack. Within the HCF, all processing and handling of the irradiated targets are performed in steel confinement boxes (SCBs) located in the heavily shielded target processing canyon. All areas of the HCF are ventilated through either the HCF exhaust stack or the HCF Zone 1a exhaust stack. The effluent from Zones 1a, 1b, and 1c is filtered by activated charcoal high-efficiency gas adsorber filters and HEPA filters. The effluent from the other zones is filtered by HEPA filters. Both the RF and HCF are maintained at a negative pressure with respect to the outdoor atmosphere. The SCBs are maintained at a negative pressure with respect to the target processing canyon.

In addition, the potential for small quantities of gaseous radionuclides, such as H-3 in the form of water vapor, may be released from the evaporation pond due to the natural evaporation process.

19.4.8.2.2.2 Liquid Sources of Radiation

The LECS collects drain water from decontamination stations and floor drains. The LECS provides holdup of water for monitoring, clean up (as needed), and ultimate release to the evaporation pond.

19.4.8.2.2.3 Fixed Sources of Radiation

LEU, molybdenum-99 (Mo-99), iodine-131 (I-131), xenon-133 (Xe-133), and other marketable radioisotope products are collected in shielded and sealed containers. The process waste is solidified in 55-gal. (208 L) drums and transferred to the waste storage canyon. Product samples are removed from the target processing canyon for quality control (QC) inspection in the HCF QC area. Instrument calibration sources reside in the QC area.

While cleanup and testing is performed prior to the LECS being released to the evaporation pond, it may still contribute to direct radiation sources existing on the EIPC due to buildup of radionuclides.

19.4.8.2.3 Baseline Radiation Levels

Baseline condition evaluations are to be made in accordance with the EIPC Radiation Protection Program. Baseline condition evaluations are made by taking soil samples and gamma surveys of the area around the site prior to commencing operations.

19.4.8.2.4 Calculated Annual TEDE Dose Estimates and Annual Airborne Radioactivity Releases

The following subsections discuss the estimated annual airborne radioactivity releases from the RF, HCF, and evaporation pond and associated total effective dose equivalent (TEDE) doses. The maximally exposed individual (MEI) is located at the north site boundary where the doses due to normal operations are expected to be maximized. The nearest residence is located west-northwest from the EMIF. The doses to the public calculated in the following subsections are considered direct effects of operation of the EMIF.

The radiation dose to the public due to transportation of radioactive waste is discussed in Section 19.4.10. The dose to the public due to the transportation of radioactive waste is considered an indirect effect of EMIF operation.

19.4.8.2.4.1 Reactor Facility

Sources of radioactive effluents are discussed in Subsection 19.4.8.2.2. Table 19.4.8-2 lists the estimated annual Ar-41 and H-3 releases from the RF exhaust stack, with no filtering, with the reactor operating at 1.8 megawatts-thermal (MWt) continuously. Also listed in the table are the estimated TEDE dose values for an MEI receptor located at the north site boundary, for the nearest work location for the URENCO facility, and for the nearest residence receptor located west-northwest from the EMIF. The TEDE dose is calculated using the COMPLY code (Version 1.7), assuming the receptor was at the location 24 hr. per day throughout the year. The wind data used was for Hobbs, NM. A 15-m (50-ft.) high stack was assumed with no exit velocity, and no building wake effects. A screening level of 4 was used in the calculation.

The dose locations represent the MEI locations, which are the site boundary, 0.31 mi. (500 m) north of the EMIF, the nearest work location for the URENCO facility, 0.85 mi (1370 m) (conservative distance), and the nearest residence, which is located at Eunice, NM, 1.7 mi. (2740 m) west-northwest of the EMIF.

Because the results in Table 19.4.8-2 are within the dose constraints given in 10 CFR 20.1301 and 10 CFR 20.1101, the radiological impacts to members of the public from the RF due to operation of the EMIF are SMALL.

19.4.8.2.4.2 Hot Cell Facility

Sources of radioactive effluents are discussed in Subsection 19.4.8.2.2. Table 19.4.8-3 shows the estimated annual noble gas and halogen releases from the HCF exhaust stack, assuming 2000 targets are processed per year, with each target irradiated at 30 kilowatts-thermal (kWt) for 25 days. The fission product inventory assumes a 4-hr. decay of the targets prior to processing. Only the isotopes contributing significantly to the receptor dose are shown. Also shown in the table are the estimated TEDE dose values for an MEI receptor located at the north site boundary, for the nearest work location for the URENCO facility, and for the nearest residence receptor located west-northwest from the EMIF. The TEDE dose is calculated using the COMPLY code (Version 1.7), assuming the receptor was at the location 24 hr. per day throughout the year. The wind data used was for Hobbs, NM. A 15-m (50-ft.) high stack was assumed with no exit velocity, and no building wake effects. A screening level of 4 was used in the calculation.

The dose location represents the MEI location, which is the site boundary, 0.31 mi. (500 m) north of the EMIF, the nearest work location for the URENCO facility, 0.85 mi. (1370 m) (conservative distance), and the nearest residence location, which is located at Eunice, NM, 1.7 mi. (2740 m) west-northwest of the EMIF. The calculated dose at site boundary for members of the public is significantly below the 100-millirem (mrem) regulatory requirement given in 10 CFR 20.1301. The calculated dose at the site boundary is above the 10-mrem As Low As Reasonably Achievable (ALARA) dose constraint for members of the public given in 10 CFR 20.1101. However, this dose is based on very conservative assumptions. For example, it is assumed that a member of the public is continuously located at the site boundary. A more realistic, but still conservative, assumption that the person is at the site boundary half the time (12 hr. per day, 365 days per year) reduces the calculated dose to less than 10 mrem. After the Operating License is granted, Eden has in place an environmental monitoring program and monitors effluents released from the EMIF to confirm that actual doses at the site boundary are within the regulatory dose constraint of 10 mrem. Therefore, the radiological impacts to members of the public from the HCF due to operation of the EMIF are SMALL.

19.4.8.2.4.3 Evaporation Pond

Sources of radioactive effluents and fixed sources of radiation are discussed in Subsection 19.4.8.2.2. During normal operation of the evaporation pond, the evaporated radionuclides, such as H-3 in the form of water vapor, cause a gaseous effluent radiation source to exist on the EIPC site. In addition, buildup of radionuclides in the evaporation pond may contribute to the direct radiation sources existing on the EIPC site. These radiation sources have the potential to impact radiation dose values to members of the public. Because the LECS provides holdup of water for monitoring, cleanup, and ultimate release to the evaporation pond, it is assumed the releases are negligible with respect to dose consequence to members of the public. After the Operating License is granted, Eden has in place an environmental monitoring program and

monitors effluents released from the LECS to the evaporation pond to confirm that actual doses at the site boundary attributable to the evaporation pond are within the regulatory dose constraints given in 10 CFR 20.1301 and 10 CFR 20.1101.

19.4.8.2.5 Annual Dose to Maximally Exposed Worker

Administrative dose limits are occupational radiation exposure limits that radiation workers at EMIF shall not exceed without prior management approval.

19.4.8.2.6 Radiation Exposure Mitigation Measures

Occupational and public exposures due to operations at the EIPC site are ALARA. This exposure minimization goal is met through both engineered and administrative controls. The following subsections discuss each individually.

19.4.8.2.6.1 Engineered Controls

The EMIF utilizes the following engineered controls to minimize radiation exposure to the public and workers:

- Incorporating ease of maintenance of repair, including ease of disassembly and modularization of components for replacement or removal to a lower radiation area for repair or disposal.
- Providing the capability to remotely or mechanically operate, repair, monitor, or inspect equipment.
- Laying out the EMIF so that access to a given area does not require passing through a higher-radiation zone area.
- Providing the ability to operate equipment from accessible areas both during normal and off-normal operating conditions.
- Providing areas outside of high-radiation areas into which equipment can be moved to for service.
- Incorporating ease of decontamination of potentially contaminated areas.
- Providing control systems so that process controls (e.g., essential instrumentation and controls) are from the lowest-radiation zone practicable.
- Controlling heating, ventilation, and air conditioning (HVAC) system contamination by maintaining ventilation air flow patterns from areas of lower radioactivity to areas of higher radioactivity.

19.4.8.2.6.2 Administrative Controls

To minimize radiation exposure to the public and workers, the EMIF utilizes administrative controls, which consist of written procedures, policies, and employee training in the following subject areas:

- Process Design for ALARA.
- Facility Design for ALARA.

- Controlled Area.
- Radiological Zones.
- Restricted Areas.
- Unrestricted Areas.
- Protective Equipment and Materials.
- Periodic Reviews of Operations, Procedures, and Practices.

19.4.8.3 Radiological Monitoring

Radiological monitoring encompasses effluent monitoring and environmental monitoring programs. The Radiological Effluent Monitoring Program addresses the monitoring, recording, and reporting of data for radiological contaminants being emitted from specific emission points such as an airborne release stack or liquid waste outfall. The Radiological Environmental Monitoring Program (REMP) addresses the monitoring of the general environmental impacts (e.g., soil, sediment, groundwater, ecology, and air) within and outside the EIPC site boundary. The following subsections provide information on the two radiological monitoring programs.

19.4.8.3.1 Radiological Effluent Monitoring

The Radiological Effluent Monitoring Program is established to identify and quantify principal radionuclides in effluents). This program is used to verify that the EIPC is performing as expected and within its design parameters, so that doses to individual members of the public remain within the limits established in 10 CFR 20.1301 and doses due to airborne emissions meet the ALARA requirement of 10 CFR 20.1101(d) as required by Regulatory Guide 4.20, Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees other than Power Reactors, Revision 1. A detailed description of the Radiological Effluent Monitoring Program, encompassing the equipment, methods, and procedures, will be provided in the Operating License Application.

All effluent pathways that could be a significant release pathway for radioactive material from the EIPC include radiological effluent monitoring.

19.4.8.3.1.1 Gaseous Effluent Monitoring

All gaseous effluents from the EIPC are released through a ventilation exhaust stack and are monitored for radioactivity.

19.4.8.3.1.2 Liquid Effluent Monitoring

As stated in Subsection 19.2.7.1.1, wastewater that may contain radioactive impurities is collected by a separate drain system and delivered to the LECS storage tank, where it is sampled for radionuclides. The LECS can utilize a suitable temporary skid-mounted cleanup system to decontaminate the water if needed. Once the water is verified below acceptable release limits and is likewise determined acceptably soluble, it is discharged to the evaporation pond. Process liquid waste is neutralized, solidified, packaged in waste drums, and temporarily stored in the basement waste storage canyon. After an appropriate decay time, the waste drums are sent in approved transport containers to a waste disposal site.

Therefore, any liquid effluent releases to the environment due to normal operations at the EIPC are under acceptable release limits. As such, an effluent release pathway to the environment is determined to be through the evaporation pond; therefore, the evaporation pond is sampled to monitor buildup of activity concentrations.

19.4.8.3.2 Radiological Environmental Monitoring

The requirement to have a REMP is documented in 10 CFR 20.1302. The REMP is used to verify the effectiveness of plant measures taken to control the release of radioactive material and to verify that measurable concentrations of radioactive materials and levels of radiation are not higher than expected based on effluent measurements and modeling of the environmental exposure pathways. Methods for establishing and conducting environmental monitoring are provided in Regulatory Guide 4.1, Radiological Environmental Monitoring for Nuclear Power Plants, Revision 2. Regulatory Guide 4.1 refers to NUREG-1301, Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors – Generic Letter 98-01, Supplement No. 1, for detailed guidance for conducting effluent and environmental monitoring. Although Regulatory Guide 4.1 and NUREG-1301 are written for nuclear power plants, due to the similarities between airborne releases of radioactivity from nuclear power plants and those expected to be released from the EIPC, guidance provided in Regulatory Guide 4.1 and NUREG-1301 were considered when developing radiological environmental monitoring for the EIPC. Specifically, guidance provided in Figure 1 of Regulatory Guide 4.1 and Table 3.12-1 of NUREG-1301 were considered when determining which exposure pathways to sample, sample locations, types of samples, and sample frequencies for the EIPC.

The following radiation exposure pathways are considered for monitoring under the REMP:

- Waterborne exposure pathway.
- Direct radiation exposure pathway monitored using thermoluminescent dosimeters (TLDs).
- Airborne exposure pathway monitored using continuous air samples.
- Ingestion exposure pathway (monitored only if triggered).

19.4.8.3.2.1 Waterborne Exposure Pathway (Groundwater Sampling)

As discussed in Subsection 19.4.4.1.1, no surface water features, such as creeks, streams, or ponds, are present on or in the immediate area surrounding the EIPC project site. As such, surface water sampling is not included in the radiological environmental monitoring plan.

Local groundwater resources are discussed in Subsection 19.3.4.1.2.3. Data from private wells within 1 mi. (1.6 km) of the project site indicates that groundwater generally flows to the northwest. Although there are no defined liquid effluent release pathways and the groundwater is not expected to be contaminated due to operation of the EIPC, based on guidance from NUREG-1301, test wells to the northwest are sampled for presence of radionuclide contaminants. Sampling is performed using the recommendations in Table 3.12-1 of NUREG-1301 (i.e., quarterly with gamma isotopic and H-3 analysis) as guidance.

19.4.8.3.2.2 Direct Exposure Pathway (Thermoluminescent Dosimeters)

TLDs provide indication of direct radiation from contained radiation sources within the EIPC. Table 3.12-1 of NUREG-1301 recommends 40 TLD locations, that is to say, an inner ring and an outer ring of TLDs with one TLD in each ring at each of the 16 meteorological sectors and the balance of TLDs located at special-interest areas. The recommendations from NUREG-1301 are used for nuclear power plants. As such, 16 TLDs are selected for the inner ring in each of the 16 meteorological sectors. In addition, one TLD is selected to serve as a control, that is to say, located at a significant distance from the facility such that it represents a background dose. Subsection 19.3.8.1, Figure 19.3.8-1, identifies the distances from the project site to the sensitive receptors. The sensitive receptors for which TLDs are considered are listed below. The actual locations for all TLDs will be determined in the Operating License Application (distances are approximate from the site centerpoint).

- Nearest full-time resident, located 1.7 mi. (2.7 km) west-northwest.
- Nearest municipal water supply system, located 18.5 mi. (29.8 km) north-northwest.
- Nearest school, located 4.1 mi. (6.6 km) west-northwest.
- Nearest medical facility, located 3.9 mi. (6.3 km) west-northwest.
- Nearest assisted-living facility, located 19.1 mi. (30.7 km) north-northwest.

19.4.8.3.2.3 Airborne Exposure Pathway (Airborne Sampling)

Airborne effluent releases from the EIPC contribute to off-site doses. Environmental airborne sampling is performed to identify and quantify radionuclides in airborne effluents. Regulatory Position C.3.b of Regulatory Guide 4.1 indicates that airborne sampling should always be included in the environmental monitoring programs for nuclear power plants because the airborne effluent pathway exists at all sites. Because the EIPC includes airborne effluent releases and radioactivity in the airborne effluent can result in measurable off-site doses, the REMP includes airborne sampling.

The guidance provided in Table 3.12-1 of NUREG-1301 is used as a recommendation to establish locations for airborne sample acquisition, sampling frequency, and type of sample analysis. Continuous air sample locations are specified in accordance with guidance provided in Table 3.12-1 of NUREG-1301. The continuous-air monitors (CAMs) that are used to obtain continuous air samples include a radioiodine canister for weekly I-131 analysis and particulate sampler which is analyzed for gross beta radioactivity and for quarterly isotopic analysis. Table 3.12-1 of NUREG-1301 suggests a CAM located a sufficient distance from the EIPC to provide background information for airborne activity, and an additional CAM location in the vicinity of a community having the highest calculated annual average ground-level deposition factor (D/Q). The EIPC proposes to use five CAMs to monitor airborne effluents surrounding the facility. The CAM locations will be determined in the Operating License Application.

19.4.8.3.2.4 Ingestion Exposure Pathway

NUREG-1301 suggests sampling of various biological media (biota monitoring) as a means to indirectly assess doses due to particulate and iodine ingestion. This type of monitoring may include sampling of soils, broad-leafed plants, fish, meat, or milk. Nuclear power plants have long monitored this pathway and have seen neither appreciable doses nor upward trending. Monitoring of ingestion exposure uses the guidance given in Table 3.12-1 of NUREG-1301.

If the results of EIPC environmental airborne samples or effluent monitor samples indicate iodine or particulates in quantities large enough to result in a calculated dose greater than that predicted for normal releases, then a more comprehensive biota monitoring campaign is undertaken.

19.4.8.3.3 Radiological Effluent and Environmental Monitoring Program Reporting

Radiological effluent and environmental monitoring reports will be provided to the NRC in accordance with NUREG-1301. A detailed description of the REMP, encompassing the equipment, methods, and procedures, will be provided in the Operating License Application.

19.4.8.3.4 Quality Assurance Program

The EIPC has a Quality Assurance (QA) Program established based on American National Standards Institute (ANSI)/American Nuclear Society (ANS) standard ANSI/ANS 15.8-1995, Quality Assurance Program Requirements for Research Reactors (R2018) (ANSI/ANS, 2018).

QA is made up of all those planned and systematic actions that are necessary to provide adequate confidence in the assessment of monitoring results. QC is made up of those QA actions that provide a means to measure and control the characteristics of measurement equipment and processes to meet established standards; QA includes QC.

QA is necessary to ensure that all radiological and nonradiological (flowrate, run time, etc.) measurements that support the radiological monitoring program are reasonably valid and of a defined quality. These programs are needed to identify deficiencies in the sampling and measurement processes and report them to those responsible for these operations so that licensees may take corrective action and to obtain some measure of confidence in the results of the monitoring programs to assure the regulatory agencies and the public that the results are valid. All steps of the monitoring process should involve QA (e.g., sampling, shipment of samples, receipt of samples in the laboratory, preparation of samples, radiological measurements, data reduction, data evaluation, and reporting of the measurement and monitoring results).

Table 19.4.8-1
Inventory of Major Nonradioactive Chemicals

Material	Quantity	Location	Notes
Diesel fuel	58,300 lb. (26,450 kg)	Outdoor storage (e.g., fire pump)	Stored as liquid and used in closed systems
Nitric acid	2250 lb. (1050 kg)	Indoor storage in PWH	Stored as liquid
Liquid nitrogen	32,100lb. (14,600 kg)	Outdoor storage in cryogenic tank	Stored as liquid under pressure; used for HCF processing
Liquid argon	12,000 lb. (5450 kg)	Outdoor storage in cryogenic tank	Stored as liquid under pressure; used in glovebox fuel fabrication

Abbreviations: lb. = pound(s) | kg = kilogram(s) | PWH = Production Warehouse | HCF = Hot Cell Facility

Table 19.4.8-2
Estimated Annual Radioactive Airborne Releases and TEDE Doses from the Reactor Facility

Radionuclide	Annual Release (Ci)	Nearest Residence Dose (mrem) 1.7 mi. (2740 m) West-Northwest	Nearest Work Location Dose (mrem) 0.85 mi. (1370 m) North-Northeast	Site Boundary (MEI) Dose (mrem) 0.31 mi. (500 m) North
Ar-41	14.7	2.50E-04	1.35E-03	1.25E-02
H-3	0.0175	5.95E-08	3.15E-07	2.80E-06
Total		**2.50E-04**	**1.35E-03**	**1.25E-02**

Abbreviations: TEDE = total effective dose equivalent | Ci = curie(s) | mrem = millirem | mi. = mile(s) | m = meter(s) | MEI = maximally exposed individual | Ar-41 = argon-41 | H-3 = tritium

Table 19.4.8-3
Estimated Annual Radioactive Airborne Releases and TEDE Doses from the Hot Cell Facility

Radionuclide	Annual Release (Ci)	Nearest Residence Dose (mrem) 1.7 mi. (2740 m) West-Northwest	Nearest Work Location Dose (mrem) 0.85 mi. (1370 m) North-Northeast	Site Boundary (MEI) Dose (mrem) 0.31 mi. (500 m) North
Kr-88	6.77E+03	2.64E-01	1.35E+00	1.22E+01
Xe-133	3.07E+04	4.30E-02	7.68E-02	7.06E-01
Xe-135	1.24E+04	4.21E-02	2.23E-01	1.98E+00
I-131	1.22E+00	2.33E-02	3.18E-02	1.22E-01
Total		**3.72E-01**	**1.68E+00**	**1.50E+01**

Abbreviations: TEDE = total effective dose equivalent | Ci = curie(s) | mrem = millirem | mi. = mile(s) | m = meter(s) | MEI = maximally exposed individual | Kr-88 = krypton-88 | Xe-133 = xenon-133 | Xe-135 = xenon-135 | I-131 = iodine-131

19.4.9 WASTE MANAGEMENT

The following subsections discuss hazardous, radioactive, nonradioactive, and mixed wastes associated with the EIPC. These wastes are generated within the facility, and these subsections describe the type and quantities generated and the systems and programs used to safely handle, process, and ultimately, dispose of the waste.

19.4.9.1 Sources and Types of Waste Created

The sources and types of waste created within the EIPC are described in Section 19.2.7. Radioactive wastes are produced within the EMIF with sources and types described in Subsection 19.2.7.3 and Tables 19.2.7-1 and 19.2.7-2. Nonradioactive and hazardous waste sources and types are described in Subsections 19.2.7.2 and 19.2.7.5.2, and Tables 19.2.7-3 and 19.2.7-4.

19.4.9.1.1 Sources of Hazardous, Nonradioactive, Radioactive, and Mixed Wastes

Radioactive wastes are primarily generated by reactor operations in the RF and reprocessing of targets and other activities in the HCF of the EMIF, as described in Subsection 19.2.7.1. Subsection 19.2.7.3 provides a list of all sources of radioactive wastes generated within the EMIF. These wastes are primarily in solid form. Some gaseous waste is also generated, but the facility is not expected to need a gaseous radioactive waste system, as described in Subsection 19.2.7.1.3. Gaseous waste is controlled through the HVAC exhaust stacks for both the RF and HCF. The exhaust stack for the RF is normally unfiltered but can be switched to a filter mode by the operator based on CAM signals from the exhaust stack. For the HCF, individual SCB exhausts are manifolded together and routed through a HEPA and charcoal filter bank before being discharged to the outside environment through the HCF exhaust stacks. Additional details on the RF and HCF HVAC systems are provided in Subsections 19.2.3.5 and 19.2.4.4, respectively.

Nonradioactive and hazardous wastes are generated by construction, routine operations, maintenance, cleaning, and decommissioning activities, in both solid and liquid form at the proposed EIPC, as described in Subsections 19.2.1.6.1, 19.2.1.6.4, 19.2.7.2 and 19.4.8.1.

19.4.9.1.2 Type and Quantity of Hazardous, Nonradioactive, Radioactive, and Mixed Wastes

The types and quantities of radioactive wastes from annual operations are provided in Table 19.2.7-1. The process waste stream is the primary waste stream from the facility. Types and quantities of radioactive wastes from EIPC decommissioning are provided in Table 19.2.7-2.

The types of nonradioactive hazardous wastes generated during construction are provided in Table 19.2.7-3 and described in Subsection 19.2.7.5.2.1. The types of nonradioactive hazardous wastes generated during operations are described in Subsection 19.2.7.5.2.2, along with an approximate bounding inventory of nonradioactive chemicals in Table 19.2.7-4. The types of nonradioactive hazardous wastes generated during decommissioning are described in Subsection 19.2.7.5.2.3.

19.4.9.2 Description of Waste Management Systems

Waste systems designed to collect, store, and process the waste from the EIPC are discussed in Section 19.2.7. This includes radioactive the waste system (Subsection 19.2.7.1) and nonradioactive and hazardous waste systems (Subsection 19.2.7.2).

Solid waste management and control measures at the EIPC include waste reduction, recycling, and waste-minimization practices during all project phases. Waste management practices at EIPC include:

- Nonradioactive solid wastes are collected and temporarily stored on-site and then transferred to a local recycling center or waste disposal site.
- Scrap metal and universal wastes are also collected and stored on-site and then recycled or recovered at an off-site-permitted recycling facility.

19.4.9.3 Waste Disposal Plans

The radiological wastes listed in Section 19.2.7 are stored on-site for a period of time before they are shipped off-site. The frequency of shipment of each type of waste is based on volume accumulated, storage capacity, and scheduling with the waste receiver. Enough storage capacity for all waste types is provided on-site to accommodate the amount of waste between shipments to the off-site disposal sites.

Specific storage and transport of radioactive and nonradioactive materials, including radioactive waste, nonradioactive waste, and other materials are provided in Section 19.2.8.

The radioactive wastes are transported to an approved off-site disposal facility as discussed in Subsection 19.2.8.5.3.

Nonradioactive waste from operations and decommissioning is transported by truck to the Lea County Landfill, approximately 1.5 mi. (2.4 km) by road.

19.4.9.4 Waste-Minimization Plan

Refer to Subsection 19.2.7.6 for a description of waste-minimization plans.

19.4.9.5 Environmental Impacts

The EIPC wastes are managed as described in the previous subsections and are managed in accordance with applicable federal, state, and local regulations. As a result, the direct impacts due to the environment due to on-site storage and disposal of waste are SMALL. Additionally, the indirect impacts to the environment from transportation and delivery of waste to off-site waste repositories are SMALL.

19.4.10 TRANSPORTATION

19.4.10.1 Nuclear Materials Transported

Nuclear materials are transported both to and from the EIPC located outside of Eunice, NM. The nuclear materials transported to the EIPC consists of LEU in the forms of oxides and metal and manufactured targets. Nuclear materials are transported from the EIPC as LEU, product, and waste. The LEU materials are recovered LEU in the oxide or metal form. The nuclear materials transported from the EIPC as product are Mo-99, I-131, Xe-133, and other radioisotopes produced from the fission product stream or by activation (e.g., lutetium-177 [Lu-177]). The wastes include process waste, activated or contaminated hardware and components no longer useful, and contaminated PPE and other contaminated materials.

Non-recoverable LEU would be removed from the site and disposed as radioactive waste or returned to the U.S. Department of Energy (DOE). Decommissioning of the proposed EIPC would include decontamination or removal of radioactive equipment and other materials that would be shipped off-site for licensed disposal. Whether material is ultimately removed from the site depends upon whether it is decontaminated down to release-criteria levels; if the release-criteria levels are achieved, then applicable equipment and materials may remain in place. Radioactively contaminated equipment and materials would be sent to the waste disposal facility in nearby Andrews, TX .

19.4.10.1.1 Transportation Modes and Projected Destinations

General target fabrication is planned to be conducted at the EIPC site throughout its operational phase. However, the initial loading of LEU targets supporting startup and early production are planned to be fabricated by the DOE complex (Y-12 facility located in Oak Ridge, Tennessee) or a commercial vendor (e.g., BWX Technologies, Inc. [BWXT], in Lynchburg, Virginia), using LEU metal supplied by Y-12. The Y-12 facility is approximately 1250 mi. (2000 km) by road from Eunice, NM. BWXT is about 1550 mi. (2500 km) from Eunice.

The medical isotopes produced at the EIPC are transported, by truck, to Lea County Regional Airport, where they are transported by air to various facilities for generator loading and distribution to medical facilities. Three to five product-delivery trips via air travel are anticipated weekly. Although economically undesirable, transportation by truck could be used as a back-up in cases where inclement weather does not permit air delivery. Highway distances from Eunice, NM, to the following facilities are:

- Curium Pharma (Maryland Heights, Missouri): approximately 970 mi. (1550 km).
- Lantheus Medical Imaging (Lantheus) facility (North Billerica, Massachusetts): approximately 2150 mi. (3450 km).
- Nordion, Inc. facility (Kanata, Ontario, Canada): approximately 2000 mi. (3200 km).

Radioactive waste from operations and decommissioning is to be transported by truck along NM-176 to a waste disposal facility in nearby Andrews, TX. The highway distance from the EIPC to a disposal facility is about 2 mi. (3.2 km), with approximately ten waste-delivery trips per year anticipated. Other alternative optional disposal sites could include:

- U.S. Ecology Washington Energy Solutions facility (Richland, Washington): approximately 1600 mi. (2600 km) from the EIPC.
- Diversified Scientific Services, Inc. facility (Kingston, Tennessee): approximately 1200 mi. (2000 km) from the EIPC.
- Energy Solutions, Clive Disposal facility (Clive, Utah): approximately 1005 mi. (1617 km) from the EIPC.

Although the proposed EIPC results in additional trips of radioactive materials to highways, based on the low number of shipments, and the nature of material to be transported, impacts to transportation modes and destinations from the proposed facility are SMALL.

19.4.10.1.2 Treatment and Packaging

The radioactive wastes generated at the EIPC are treated and packaged as discussed in Section 19.2.8. Solid waste includes used components and equipment. This material is collected, stored in the facility to allow for radioactive decay, and then size-reduced and consolidated for shipment as low-specific activity low-level waste (LLW) material. Higher-activity waste is, alternatively, processed and solidified prior to shipment.

Medical isotope products are extracted from the LEU targets at the end of each irradiation cycle. The target is removed from the transfer canal and transferred to the HCF, where isotopes are selectively extracted. Purified Mo-99, I-131, Xe-133, and Lu-177 are tested by QC before being packaged for shipment to the various customer facilities.

As detailed in Subsection 19.2.8.4, prior to shipment, all radioactive material is packaged to meet U.S. Department of Transportation and NRC requirements for the transportation of radioactive materials. Consequently, there are no direct or indirect impacts from the EIPC on the human environment from the treatment and packaging of radioactive materials. Impacts from treatment and packaging of radioactive materials from operation and decommissioning of the EIPC are SMALL.

19.4.10.1.3 Incident-Free Radiological Doses

The incident-free radiological doses are determined for the workers involved with and members of the public affected by the transportation of the medical isotopes and the radioactive wastes.

The calculation of the incident-free radiological doses is performed using Radioactive Material Transport (RADTRAN) code (Version 6.02) and the Transportation Routing Analysis Geographic Information System (TRAGIS) Routing Engine (Version 6.0). The RADTRAN computer code is used to calculate the doses to the workers and the members of the public using the routes defined by TRAGIS and 2010/2012 population data from U.S. Census Bureau (USCB). Most of the medical isotopes are shipped by air, and the doses associated with this transport mode are smaller than the transportation from land routes due to shorter exposure time to the workers and the smaller number of exposed members of the public during air transportation.

The TRAGIS computer code is used to determine the highway route distances traveled for a shipment from the EIPC to a regionally close airport, from a destination airport to a nearby customer facility, and distance to a waste disposal facility. TRAGIS also provides the population density along the route, which is required for calculating the dose to members of the public. However, the TRAGIS population module was unavailable through Oak Ridge National

Laboratory's online resource portal for code execution. Therefore, generic (i.e., national average) population densities are alternatively employed for rural, suburban, and urban zones of passage. This is done by superimposing the routes generated by TRAGIS on the population profile from the USCB. Summaries of the population densities along the transportation routes analyzed are provided in Tables 19.4.10-1 through 19.4.10-3.

Using the TRAGIS output, the regions that contain segments of each transportation route are classified as rural, suburban, or urban population zones. In TRAGIS, a population density between 0 and 139 people per square mile (mi^2) is considered a rural population density range (69.5 people/mi^2 being the midpoint of the range and the assumed representative value employed in RADTRAN for rural zones). A population density between 139 and 3326 people/mi^2 is considered a suburban population density range (1733 people/mi^2 being the midpoint of the range and the assumed representative value employed in RADTRAN for suburban zones). A population density greater than 3326 people/mi^2 is considered an urban population density (3326 people/mi^2 is the assumed representative value employed in RADTRAN for urban zones. Therefore, in cases where there are multiple population zones in a region of the transportation route, the population zone with the highest population density is identified and assumed for the region.

TRAGIS provides a count of the total exposed population within 800 m (243.8 ft.) of the route. Tables 19.4.10-1 through 19.4.10-3 categorize the exposed populations along the transportation routes. The analysis for determining the exposed populations along the transportation routes is performed in a conservative method to ensure the calculated dose values bound the TRAGIS values once the computer code is updated to internally include the population density data.

The dose due to transportation of the radioactive waste is calculated for shipments to the WCS facility in Andrews, TX (bounded at 40 shipments/year). Additional disposal sites considered are discussed in Subsection 19.4.10.1.1. The U.S. Ecology LLW facility in Richland, Washington, is quantitatively evaluated in the transportation analysis. The doses due to transportation of radioactive waste to the Diversified Scientific Services, Inc. facility and the EnergySolutions facility are not calculated. This is because they are bounded by the doses associated with transportation of radioactive wastes to the WCS and the U.S. Ecology LLW facility, primarily due to the smaller travel distance, which reduces the exposure time to the workers and to the members of the public.

The doses due to the transportation of the medical isotopes are calculated using scenarios based on truck shipments to the Lea County Regional Airport in Hobbs, NM, where they are transported by air to various facilities (e.g., Spirit of St. Louis Airport and Boston Logan International Airport) and distributed to medical facilities (e.g., Curium Pharma and Lantheus facility). The Midland International Air and Space Port in nearby Midland, TX, as well as the Fort Worth Meacham International Airport in Fort Worth, TX, are considered alternatives to Lea County Regional Airport in the transportation analysis. The medical facilities considered are the Curium Pharma facility in Maryland Heights, Missouri, and the Lantheus facility in North Billerica, Massachusetts. The medical isotopes are transported by truck from the respective regional/local airport (i.e., Spirit of St. Louis for the Curium facility and the General Edward Lawrence Logan [aka Boston Logan] International Airport for the Lantheus facility) to the medical facility. The estimated total number of shipments per year is 150, or three shipments per week. Most of the truck shipments may be sent to the closest facility, which is Curium, because of the short half-life of the medical isotopes. Transportation of medical isotopes exclusively by truck from the EIPC to the various medical facilities is not deemed economically feasible (primarily due to the short half-life of Mo-99) and is not evaluated.

The doses associated with the transportation of fresh or recovered LEU metal are much smaller than the doses associated with the transportation of either medical isotopes or waste material and are not calculated. The doses associated with the transportation of the LEU metal are much smaller because of the infrequent shipments (less than one per year) and the low activity in each shipment. The doses associated with the transportation of LEU materials are very low because most of the nuclides are alpha emitters, which pose no external dose hazard.

The annual incident-free radiological doses due to transportation of radioactive materials from the EIPC are summarized in Table 19.4.10-4. The doses are calculated assuming the dose rates due to the shipping containers (i.e., CROFT and MIDUS) are equal to dose rates based on NRC Safety Evaluation Reports and certifications for the respective shipping containers. The doses are determined by using the dose to transport waste to the WCS facility, transporting the medical isotopes to the Lea County Regional Airport, and transporting the medical isotopes from the Boston Logan International Airport to the Lantheus facility. The maximum dose to the workers due to the transportation of radioactive material from the EIPC site is 5.01E-04 person-sievert (Sv)/year (5.01E-02 person-rem/year). The maximum dose to the members of the public due to the transportation of radioactive material from the EIPC site is 2.16E-03 person-Sv/year (2.16E-01 person-rem/year). Therefore, the incident-free radiological doses from transportation of medical isotopes and radioactive waste are SMALL.

19.4.10.1.4 Non-Nuclear Materials Transported

Nonradioactive waste (e.g., paper and plastic) is recycled in accordance with local processes. General office supplies and industrial supplies supporting the maintenance and day-to-day operation of the facility are transported to the site. Office waste is generated at the site and transported from the site without being treated or packaged to the Lea County, NM, landfill, approximately 1.6 mi. (2.6 km) east of the EIPC project site east boundary. These activities are typical for a general commercial facility within Lea County. The associated incident-free transportation activities do not have an adverse impact on the environment, workers, or the members of the public. Therefore, construction and operation-related direct and indirect impacts from non-nuclear material transportation are SMALL.

Table 19.4.10-1
Population Density and Exposed Population for Transportation Routes to Departing Airports

Departure Airport	Zone	Distance Traveled (mi.)	Distance Traveled (km)	Population Density National mean (persons per mi^2)	Population Along Route Segment
Lea County Regional Airport	Rural (low)	18.2	29.3	69.5	1265
	Suburban (medium)	3.7	5.9	1733	6412
	Urban (high)	0.8	1.3	3326	2661
	Total	**22.7**	**36.5**		**10,338**
Midland International Air and Space Port	Rural (low)	63.6	102.3	69.5	4420
	Suburban (medium)	16.6	26.7	1733	28,768
	Urban (high)	3.8	6.1	3326	12,639
	Total	**83.9**	**135**		**45,827**
Fort Worth Meacham International Airport	Rural (low)	289.2	465.3	69.5	20,099
	Suburban (medium)	72.9	117.3	1733	126,336
	Urban (high)	18.6	29.9	3326	61,864
	Total	**380.7**	**612.5**		**208,299**

Abbreviations: mi. = mile(s) | km = kilometer(s) | mi^2 = square mile(s)

Table 19.4.10-2
Population Density and Exposed Population for Transportation Routes from Destination Airports to Customer

Airport to Destination	Zone	Distance Traveled (mi.)	Distance Traveled (km)	Population Density National mean (persons per mi^2)	Population Along Route Segment
Spirit of St. Louis Airport to Curium Facility	Rural (low)	0	0	69.5	0
	Suburban (medium)	13.9	22.4	1733	24,089
	Urban (high)	8.7	14	3326	28,936
	Total	**22.6**	**36.4**		**53,025**
General Edward Lawrence Logan (aka Boston Logan) International Airport to Lantheus Medical Imaging Facility	Rural (low)	0	0	69.5	0
	Suburban (medium)	20	32.2	1733	34,660
	Urban (high)	13.5	21.7	3326	44,901
	Total	**33.5**	**53.9**		**79,561**

Abbreviations: mi. = mile(s) | km = kilometer(s) | mi^2 = square mile(s)

Table 19.4.10-3
Population Density and Exposed Population for Transportation Routes of Low-Level Waste

Disposal Location	Zone	Distance Traveled (mi.)	Distance Traveled (km)	Population Density National mean (persons per mi^2)	Population Along Route Segment
Waste Control Specialists (WCS)	Rural (low)	1.5	2.41	69.5	104
	Suburban (medium)	0	0	1733	0
	Urban (high)	0	0	3326	0
	Total	**1.5**	**2.41**		**104**
U.S. Ecology Disposal Facility	Rural (low)	1258	2024	69.5	87,431
	Suburban (medium)	253.3	407.6	1733	438,969
	Urban (high)	52.6	84.6	3326	174,948
	Total	**1564**	**2516**		**701,348**

Abbreviations: mi. = mile(s) | km = kilometer(s) | mi^2 = square mile(s)

Table 19.4.10-4
Incident-Free Radiological Dose Summary (Person-Rem/Year)

	LLW 10-160B Cask (40 total shipments/year)		Product[a]						
Receptor	**WCS**	**U.S. Ecology[b]**	**Product Cask**	**Lea County Airport**	**Midland Airport**	**Fort Worth Airport**	**Curium**	**Lantheus**	**Estimated Totals[c] (LLW + Product)**
Workers	0.0011	>0.11	CROFT	0.017	0.063	0.29	0.021	0.032	0.0501
			MIDUS	0.011	0.042	0.19	0.014	0.021	0.0331
Members of the Public	0.0021	>0.21	CROFT	0.064	0.24	0.58	0.1	0.15	0.216
			MIDUS	0.062	0.23	0.57	0.1	0.15	0.214

a) Assumes 150 shipments per year for each option. For the MIDUS Product Cask, there are two casks per shipment at 4400 Ci of Mo-99 per cask. For the CROFT Product Cask, there are nine casks per shipment at 1000 Ci of Mo-99 per cask.
b) An aggregate dose increase of two to three orders of magnitude to both workers and members of the public is estimated for hypothetical waste shipments to Richland versus to WCS, due to significantly higher mileage traveled and a much larger exposed population.
c) Based on Hobbs (Lea County Regional Airport) for assumed product departure, Lantheus for all 150 shipment deliveries (dose results are higher than to Curium in all cases), and delivery of LLW exclusively to WCS.
Abbreviations: LLW = low-level waste | WCS = Waste Control Specialists | U.S. = United States | Ci = curie(s)

19.4.11 POSTULATED ACCIDENTS

This subsection identifies the postulated initiating events (IEs) and credible accidents for the EIPC that were selected to drive the design of the facility; designated herein as postulated events (PEs). This subsection also describes the maximum hypothetical accident (MHA).

19.4.11.1 Methodology for Identification of Design Basis Accidents

The methodology for identifying PEs is described in Chapter 13.

The EMIF has been divided into two major areas: (1) the RF and (2) the HCF. The RF consists of the reactor, reactor pool, and supporting structures, systems, and components dedicated to the irradiation of targets. The HCF includes the operations with special nuclear material (SNM), radiochemical operations, and operations with hazardous chemicals.

According to the ISG Augmenting NUREG-1537, the following accident categories, as modified for the EMIF, are to be addressed for the RF and HCF:

- MHA.
- Insertion of excess reactivity.
- Loss of coolant.
- Loss of coolant flow.
- Mishandling or malfunction of fuel.
- Experiment malfunction.
- Loss of normal electrical power.
- External events.
- Mishandling or malfunction of equipment.
- Operator error.
- Facility fire.
- Criticality accidents.
- Hazardous chemical releases.

All IEs and scenarios applicable to the RF are evaluated in Chapter 13a. Those applicable to the HCF areas are covered in Chapter 13b.

Representative accident scenarios with bounding consequences for each of the above IEs/scenario categories are evaluated quantitatively in Sections 13a.1, 13a.2, 13b.1, 13b.2 and 13b.3 per the guidance in NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content, and the ISG Augmenting NUREG-1537. The bounding PEs with respect to consequences for both the RF and the HCF are analytically evaluated in Subsection 19.4.11.2 below.

19.4.11.2 Identified Initiating Events and Design Basis Accidents

This subsection discusses quantitatively the consequences of the MHA. This subsection also briefly discusses IEs and PEs, as well as some of the controls designed to prevent or mitigate the potential consequences to levels that are acceptable (i.e., within regulatory criteria). These IEs and PEs are designed to bound the potential accident scenarios in each of the accident categories of interest.

Maximum Hypothetical Accident

The MHA is defined as a fission product release accident that results in radiological consequences that exceed those of any fission product release accident considered to be credible. The MHA, therefore, bounds the radiological consequences of PE scenarios at the EMIF. The MHA need not be a credible scenario, but a failure is assumed to establish an outer limit consequence.

For the EMIF, the MHA is based on events unique to the facility that hypothetically could result in a release of radioactive materials. As noted above, the EMIF is subdivided into two major process areas: (1) the RF and (2) the HCF. The facility is designed to withstand credible external events. As such, external events are not considered as the MHA. Therefore, an internal accident releasing the largest possible quantity of radioactive material is considered to be the IE that would result in the maximum bounding radiological consequence.

The RF and HCF are designed to function as two independent facilities within the EMIF. Though the RF and HCF have processes and systems that interact with each other, they are separated by a shared wall and transfer canal to maintain separate confinement control, mentioned in Section 19.2.3. Because of this separation, it is necessary to analyze both the RF and HCF to determine the MHA.

The criterion for radiation dose during an accident to an individual member of the public is 1.0 rem, TEDE to the whole body. This is applied at the 500-m (1640-ft.) site boundary or, alternatively, at the maximum dose exposure distance from the facility (600 m) (1969 ft.) for a member of the public. This dose limit is established by NUREG-1537; 10 CFR 50.34(a)(1)(i); 10 CFR 20.1301; and 10 CFR 20.1201. The MHA is used to demonstrate that the maximum consequences of an accident at the EMIF are within this regulatory limit. The MHA assumes a failure that results in a radioactive release with radiological consequences that bound all credible PEs.

The MHA for the RF is the overheating and melting of an LEU foil in a target from fuel/cladding interface delamination. This potential MHA assumes 0 hr. of decay time. This event occurs within the reactor pool. The calculated radionuclide inventory released from the target to the reactor pool represents the bounding source term for any other postulated accident in the RF.

Controls to mitigate the consequences of the MHA in the RF are:

- The pool water is effective in scrubbing the halogens and other nuclides.
- Operation of the stack ventilation system during reactor operation. The ventilation system is provided but not required to operate to meet the dose criterion.
- Radiation area monitors and CAMs operating in the high bay at specific locations during reactor operations and irradiated target transfer activities.

The MHA for the HCF is a release of iodine from iodine traps due to a fire. This event occurs within one of the SCBs within the target processing canyon where the iodine traps are being staged for processing. The calculated radionuclide inventory released from the SCB represents the bounding source term for any other postulated accident in the HCF.

Controls to mitigate the consequences of the MHA in the HCF are:

- Hot cell construction reduces the likelihood of failure of the hot cell structure during seismic and natural phenomena events and accidents within the hot cell (fires, releases/spills, chemicals), and reduces the likelihood of a fire in the SCBs during periods of staging waste.
- The HCF Zone 1a ventilation system is required to be operating during processing activities in the confinement boxes.
- HCF Zone 1a stack exhaust filtering uses charcoal filters to lower the dose at the site boundary.
- Limiting the maximum number of targets that can be processed in a dissolver box.

The evaluation of the inventory for the considered MHAs is based on a set of limiting initial conditions that are designed to maximize the potential source terms and to bound credible scenarios.

The amount of radioactive material released to the environment (i.e., source term) is calculated for both MHAs based on Equations 19.4.11-1 (RF) and 19.4.11-2 (HCF) below:

$$ST_i = MAR_i \times MRF_i \times PRF_i \times RRF_i. \quad \text{(Equation 19.4.11-1)}$$

$$ST_i = MAR_i \times MRF_i \times LPF_i \quad \text{(Equation 19.4.11-2)}$$

where:

ST_i is the Source Term for the specific radionuclide *i* leaving the RF or HCF in units of activity.

MAR_i is the Material at Risk for the radionuclide *i,* in units of activity.

MRF_i is the Matrix Release Fraction for the radionuclide *i* (in the evaluated cases assumed to be 1.0).

PRF_i is the Pool Release Fraction for the radionuclide *i.*

RRF_i is the Room Release Fraction for the radionuclide *i.*

LPF_i is the Leak Path Fraction for the radionuclide *i.*

For the RF postulated scenario, the entire inventory of one target is released to the reactor pool.

For the HCF postulated scenario, the radioactivity in 12 iodine traps is released to the SCB.

For dose calculations, two release scenarios are considered, that is, a ground release and a release from the 15-m (50-ft.) stack. Atmospheric dispersion is determined based on F stability and 1 meter per sec. (3 ft/sec) wind speed.

The TEDE for the postulated MHA are:

- RF: TEDE of 3.57E-01 rem at the site boundary assuming a ground release and 7.90E-02 rem at 600 m (1969 ft.) assuming a stack release.
- HCF: TEDE of 5.24E-01 rem at the site boundary assuming a ground release and 1.17E-01 rem at 600 m (1969 ft.) assuming a stack release.

Based on the calculated doses, these values are acceptable and are less than the regulatory limit of 1.0 rem. Impacts from the postulated MHA are SMALL.

19.4.11.2.1 Reactor Facility

19.4.11.2.1.1 Insertion of Excess Reactivity

Excess reactivity insertion from the control rod bank withdrawal is identified as a potential PE for the RF that needs to be evaluated.

The RF has several safety-related controls for the reactor protection system (RPS). Two RPS neutron monitoring systems are required to be operating during reactor operations. Each RPS neutron monitoring system has one calibrated power level trip and one calibrated period level trip. Any of the two bi-stable trips in a system would cause a scram. The operating power level for the reactor is 1.8 MWt or less, with a power level trip of 2.0 MWt. The reactor period level trip is 5 sec. or greater. The delay time from initiation of a scram actuation to start of control and safety rod motion downward into the core is 0.5 sec. or less. As such, there are no radiological consequences from this event.

19.4.11.2.1.2 Loss of Coolant

The loss of cooling event is identified as a potential PE. This scenario, however, is bounded by the MHA event because there is no consequence from loss of cooling in the RF. Examples include:

- A leak or break in the primary coolant line, either the intake or return line.
- A leak or break in the cleanup loop system.
- A leak in a seal on a pump, flange, or valve.
- A leak in the heat exchanger or cleanup resin beds.
- Operator error (inadvertent manual line up of valves to remove water from the pool).

The design of the reactor tank and pool in the RF is such that the loss of cooling (even without engineering features) does not result in fuel melting or cladding failures. Any water removed from the reactor tank would be retained in the LECS. Water removed from the tank by a break or leak is captured in one of the auxiliary equipment rooms in the high bay and pumped to the LECS using an automatic sump pump. The balance-of-plant (BOP) system actuates a sump pump alarm when a sump pump is automatically actuated, pumping water to the LECS.

The design of the pool limits the amount of water that can be removed from the pool. The only intake lines that can remove water from the pool are the coolant heat rejection system and the cleanup loop system, which only extend 10.6 ft. (3.2 m) below the “filled” level into the pool. At that point, no additional water can be removed from the pool.

The BOP system at the control console includes reactor pool water level indication and reactor pool water level alarms to allow the operator to continuously monitor the reactor pool water level. Regular surveillance walkthroughs of the RF are planned during the operational shift and any deviations in reactor pool water level are promptly reported to the RF supervisor. If the pool coolant level continues to drop, a low reactor pool water level scram is initiated.

No fuel melting or cladding failures occur for this accident scenario. No consequences occur for a partial loss of water from the pool.

19.4.11.2.1.3 Loss of Coolant Flow

The loss of coolant flow affects the RF and is identified as a potential PE. This scenario, however, is bounded by the MHA event because there is little or no consequence from loss of coolant flow in the RF. Examples include:

- Loss of cooling system flow (LOF-1).
- Loss of cooling system heat sink (LOF-2):
  - Failure or malfunction in the secondary side of the heat rejection system (secondary side pumps or cooling tower fans fails).
  - Failure of the primary coolant pumps to operate.
  - Operator inadvertent action, turning off pumps or fans.
  - Faulty indications leading the operator to take incorrect action, turning off equipment unnecessarily.
- Overheating of a target element due to flow blockage.

The design of the heat rejection system includes redundancy in the primary pumps, heat exchangers, secondary pumps, and cooling towers and fans. The operation of the system is controlled at the control console using the BOP system, which observes and records temperatures, flow rates, and functionality of the heat rejection system. An out-of-range warning indication actuates when the heat rejection system performs outside of normal operating range. Furthermore, the operators perform surveillance walkthroughs of the facility during the operational shift, as discussed in Subsection 19.4.11.2.1.2.

The design of the core inlet downcomer acts to prevent objects from possibly blocking the lower grid plate structure. A screen on the top of the core inlet downcomer prevents objects from falling into or being sucked into the core inlet downcomer. A complete blockage is not credible because control and safety rod guide tubes limit the accessibility to the lower grid plate.

The reactor pool water heats up until operator action is taken. If the operator does not act, the reactor continues to operate at full power until the inlet coolant temperature scram setpoint is reached. At this point, the RPS ensures that the temperature limit for the targets is not exceeded.

No fuel melting or cladding failures occur for this accident scenario. No consequences occur for a loss of cooling system flow (LOF-1) or loss of cooling system heat sink (LOF-2). No consequences occur for a partial flow blockage of the lower grid plate.

19.4.11.2.1.4 Mishandling or Malfunction of Targets

The following events are identified as potential PEs representing the mishandling or malfunction of fuel:

- Dropped/mishandled irradiated target element.
- Mishandled irradiated target transfer basket.

One or several irradiated targets are dropped in the pool during transfer or the irradiated target transfer basket holding irradiated targets falls over, dumping the irradiated targets into the pool or transfer canal. The targets could be breached as a result of hitting the floor or other objects. For this accident scenario, it is assumed that 24 targets are damaged with the target cladding breached, allowing for noble gas fission products to be released into the pool.

The consequences for this event are 9.5E-04 rem TEDE at the site boundary assuming a ground release and 2.4E-04 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the RF MHA.

19.4.11.2.1.5 Experiment Malfunction

Experiment malfunction due to canister failure or melt of the activation material due to overheating in the RF is identified as a potential PE. The rupture of a canister could damage nearby targets.

For this analysis, the accident scenario investigated is a failure of an irradiation/activation canister due to over-pressurization and rupture. If the canister was in the reflector region near the targets, the rupture could damage three adjacent targets.

The consequences for this event are 1.2E-04 rem TEDE at the site boundary assuming a ground release and 2.9E-05 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the RF MHA.

19.4.11.2.1.6 Loss of Normal Electrical Power

The loss of normal electrical power affects the RF and is identified as a potential PE.

As described in Chapter 7a, a complete loss of normal electric power in the RF causes the RPS to trip circuits to scram the system and de-energize the electromagnets on each of the four control rods and safety rod, which allows them to fall by gravity into their most negative reactivity position in the core. A partial loss of electric power in the RF could lead to an event that causes loss of the high bay ventilation system or loss of the reactor coolant system. In cases where the RPS does not scram the reactor due to partial loss of electrical power, the reactor operator manually scrams the reactor if it is deemed that the reactor cannot be operated safely.

There are no consequences for the loss of electrical power in the RF. As such, this event is bounded by the MHA.

19.4.11.2.1.7 External Events

Postulated external events have been identified as follows:

- Earthquake.
- Tornado or high winds.
- Precipitation.
- External flood.
- Off-site stationary and transportation accidents.

In summary, due to the EMIF design features, as described below, there are no consequences to members of the public because of postulated external events.

Earthquake — The project site near Eunice, NM, is in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the EIPC is low.

The safety-related structures constructed of reinforced concrete are designed in accordance with the applicable load combinations from ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures (ACI, 2014). The safety-related structures constructed of structural steel are designed in accordance with the applicable load combinations from ANSI/American Institute of Steel Construction (AISC) standard ANSI/AISC N690-18, Specification for Safety-Related Steel Structures for Nuclear Facilities (ANSI/AISC, 2018).

The nonsafety-related portion of the EMIF is designed to the local building code, which is the International Building Code (ICC, 2021). The local building code for the EMIF invokes American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) ASCE/SEI 7--16, Minimum Design Loads for Buildings and Other Structures, for minimum design load requirements (ASCE/SEI, 2017). Thus, the nonsafety-related portion of the EMIF main force resisting system (MFRS) is designed to prevent collapse during a design basis seismic event to ensure it does not negatively impact the safety-related portion of the EMIF.

Tornado or high winds — The design of the EMIF provides protection for safety-related structures, systems, and components (SSCs) against adverse effects from winds. SSCs whose failure during a tornado event could affect the safety-related portions of the facility are designed to resist the tornado loading or, alternatively, the effect on the safety-related structures from the failure of these SSCs, or portions thereof, is evaluated to ensure no safety function is compromised. In addition to local impact effects, the barriers and building structures are designed to resist the overall effects of missile impact.

Precipitation — The meteorological characterization of the EIPC site defines the precipitation characteristics. Precipitation categories include rain, snow, and ice. The exterior shell of the EMIF over the RF and HCF is provided with adequate primary and secondary drains to keep rainwater to a level such that it does not govern the design. Therefore, loads due to rain accumulation are not considered in the structural design. Similarly, because rain accumulation does not occur, load due to ice is anticipated to be minimal and is thereby enveloped by the snow load.

External flood — The only potential for flooding of the EMIF results from local intense rainfall. Protection against flooding is provided by establishing the facility floor level above the high point of finished grade elevation and all roads below this. In addition, to prevent general site flooding from the contributory areas above the site, diversion ditches are strategically located around the site to deflect surface runoff from adjacent land away from the facility structures on the site.

There are no external flood loads on the above-grade portion of the EMIF. The portion of the EMIF below-grade (e.g., reactor pool, transfer canal, waste storage canyon, HCF target fabrication area, and other HCF basement areas) could be subjected to grade-level hydrologic loads. The EMIF is designed to withstand buoyant forces and groundwater, including groundwater associated with the design basis flood.

Off-site stationary and transportation accidents — The facilities and routes within 5 mi. (8 km) of the EIPC were evaluated to determine the hazards:

- An uninhabitable reactor control room due to toxic vapors.
- Damage to EIPC structures due to explosive overpressure from stationary explosions.
- Damage to EIPC structures due to explosive overpressure from delayed ignition explosions.
- Damage to safety-related structures and equipment due to radiative heat transfer.

The results of these analyses concluded that none of the chemical sources, off-site facilities, or transportation routes pose a hazard to the EIPC.

19.4.11.2.1.8 Mishandling or Malfunction of Equipment

The potential PEs initiated by the mishandling or malfunction of equipment include:

- Heavy load drop on reactor core in the RF resulting in damage to the target elements.

For this accident scenario, it is assumed that all 60 targets are damaged, and the target cladding breached allowing for noble gas fission products to be released into the pool with no decay assumed for the fission products.

The consequences for this event are 2.38E-03 rem TEDE at the site boundary assuming a ground release and 5.9E-04 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the RF MHA.

Consequences due to a heavy load being dropped onto the core are further reduced by performing maintenance and crane operations while the reactor is in shutdown.

The consequences from these scenarios are bounded by the MHA.

19.4.11.2.2 Hot Cell Facility

19.4.11.2.2.1 Loss of Normal Electrical Power

The loss of normal electrical power affects the HCF and is identified as a potential PE.

Electrical power to the HCF includes normal off-site electrical power from the grid, standby diesel generators, and an uninterruptible power supply system (UPSS). During normal operations, the HCF electrical systems are provided power from off-site electrical power. If off-site electrical power is lost, standby diesel generators are used to complete process activities in the HCF by providing electrical power to the HCF ventilation system and other required systems. If standby diesel generator power is unavailable, the UPSS provides electrical power to the HCF ventilation system Zone 1a components.

Off-site electrical power could be lost to the HCF during target uranium (U) foil dissolution or other isotope processing activities. The HCF ventilation system is required to be operating during processing activities in the target processing canyon. Standy diesel generators are used to provide electrical power to selected systems in the HCF, including the HCF ventilation system, to complete process activities during off-site power outages. For all activities performed in the HCF during an electrical power outage with no standby power, operators place the work in a safe condition.

There are no consequences for the loss of electrical power in the HCF. As such, this event is bounded by the MHA.

19.4.11.2.2.2 External Events

The potential external event identified as PEs for the EMIF is from a seismic event affecting the HCF.

For this PE, the worst-case condition is the release of noble gases due to a seismic event in the HCF. This event assumes that immediately after processing and evacuation of the dissolver system into the noble gas delay system, a seismic event occurs that causes components to fail in the system, releasing all of the contents of the system to the dissolver box. The noble gas inventory for six irradiated targets (30 kWt each) from the day's operation (decayed 6 hr.) and six irradiated targets from the previous day's operation (decayed 30 hr.) are assumed to be released through a ground level release or through the HCF Zone 1a exhaust stack.

The consequences for this event are 1.61E-01 rem TEDE at the site boundary assuming a ground release and 4.0E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

19.4.11.2.2.3 Critical Equipment Malfunction

The potential PEs initiated by the mishandling or malfunction of equipment include:

- Dissolver vessel during dissolution activities in the HCF.
- Dissolver vessel seal leak during dissolution activities in the HCF.
- Failure of a component in the fission gas delay system in the HCF.

Any releases from the HCF due to a rupture or leak during dissolution activities and failure of a component in the noble gas delay system are mitigated by checking for leaks by ensuring that the vacuum holds for a designated period of time, requiring use of the HCF ventilation system during processing activities, and ensuring that a number of components are single-use and replaced after every use. A pressure control valve on the gaseous side of the dissolver vessel

system allows for gases and liquids to be captured in a separate reserve vessel in the dissolver box if the dissolver vessel pressure exceeds the maximum allowable working pressure setting.

Dissolver Vessel Rupture

It is assumed that the accident occurs after 6 hr. of decay and that all the U foils have been dissolved in the nitric acid when the event occurs. The dissolver unit is assumed to be breached, spilling the contents of the vessel in the dissolver box. All the noble gases, halogens, other fission products, and actinides are assumed to be released into the dissolver box.

The consequences for this event are 4.12E-01 rem TEDE at the site boundary assuming a ground release and 9.3E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

Dissolver Vessel Seal Leak

It is assumed that the accident occurs after 6 hr. of decay and that all the U foils have been dissolved in the nitric acid when the event occurs. The dissolver unit is assumed to leak in the free space region of the dissolver unit, releasing the noble gases and halogens into the dissolver box. All the noble gases and halogens are assumed to be released into the dissolver box.

The consequences for this event are 2.6E-01 rem TEDE at the site boundary assuming a ground release and 6.0E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

Fission Gas Delay System Rupture

The consequences for this accident are the same as for the previous dissolver vessel seal leak. The dissolver unit is designed to process up to six targets. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay during the evacuation process of the dissolver unit using the Fission Gas Delay System (FGDS). All the noble gases and halogens are assumed to be released into the dissolver box.

19.4.11.2.2.4 Operator Error

Operator error is identified as a potential PE. The dissolver system not being evacuated properly due to operator error after a target dissolution activity results in the noble gas delay system releasing all of the noble gas contents of the dissolver vessel into the dissolver box and ultimately to the environment via the HCF filtration system. This event is similar to the dissolver seal leaks during dissolution activities in Subsection 19.4.11.2.2.3.

The dissolver unit is designed to process up to six targets. Only one dissolver unit is operated at a time per dissolver box. It is assumed that the accident occurs after 6 hr. of decay during the evacuation process of the dissolver unit using the FGDS. All the noble gases and halogens are assumed to be released into the dissolver box.

The consequences for this accident are the same as for the previous dissolver unit seal leak in Subsection 19.4.11.2.2.3. That is, 2.6E-01 rem TEDE at the site boundary assuming a ground release and 6.0E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

19.4.11.2.2.5 Facility Fire

The following events are identified as potential PEs involving a facility fire:

- U foil ignites during target disassembly.
- Fire due to combustible materials or electrical short in the uranium extraction (UREX) box.

Uranium Foil Ignites During Target Disassembly

During irradiated target disassembly in a dissolver box, a U foil ignites, releasing all its fission product and actinide inventory into the dissolver box. For this accident it is assumed that an irradiated U foil ignites and releases all the fission products and actinides from one target that was irradiated at full power for 25 days and decayed for 4 hr. All the noble gases, halogens, other fission products, and actinides are assumed to be released into the dissolver box.

The consequences for this event are 8.0E-02 rem TEDE at the site boundary assuming a ground release and 1.8E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

Fire Due to Combustible Materials or Electrical Short in UREX Box

For this accident it is assumed that the tributyl phosphate/dodecane solution ignites in the UREX box while U purification activities are being performed. It is assumed that there are no noble gas or halogen fission products in the U solution because these were removed during the dissolution process in the dissolver box. During the fire, it is assumed that the actinides and other fission products are released into the UREX box. It is further assumed that the inventory from six irradiated targets irradiated at 30 kWt for 25 days and decayed for 6 hr. is released.

The consequences for this event are 1.52E-01 rem TEDE at the site boundary assuming a ground release and 3.2E-02 rem TEDE at 600 m (1969 ft.) assuming a stack release. These values are below the regulatory limit of 1.0 rem and are bounded by the HCF MHA.

19.4.11.2.2.6 Criticality Accidents

Criticality accidents are identified as PEs for the target processing canyon, waste storage canyon, SNM storage, and the target fabrication areas affecting the HCF. The following events are identified as potential PEs involving criticality accidents:

- Target processing canyon and waste storage canyon:
  - Nuclear criticality in dissolver box.
  - Nuclear criticality in UREX box.
  - Nuclear criticality in cask loading bay.
- SNM storage area:
  - Nuclear criticality in SNM storage area.
- Target fabrication area:
  - Nuclear criticality in SNM blending area.
  - Nuclear criticality in oxide to metal reduction area.
  - Nuclear criticality in ingot to foil production area.
  - Nuclear criticality in foil to target production area.

A criticality event in the canyon area is prevented by controlling the number of targets that can be in the target receipt box, dissolver box, and the UREX box and by limiting the amount of LEU that can be in a waste barrel during waste packaging and storing. A criticality event in the SNM storage is prevented by arranging and organizing material in storage units and racks to remain criticality safe under flooded and double-contingency conditions. A criticality event in the target fabrication areas is prevented by limiting the amount of oxide powder and LEU metal in the form of metal ingots, foils, and targets in the glovebox.

The EMIF maintains a robust Nuclear Criticality Safety Program, and Criticality Safety Evaluations are performed on all activities in the HCF requiring SNM LEU usage, transfer, or storage by Criticality Safety Engineers.

19.4.11.2.2.7 Hazardous Chemical Releases

The methodology for determining the spill area release rate from evaporation is presented in NUREG/CR-6410, Nuclear Fuel Cycle Accident Analysis Handbook, formulas B.3 through B.5. The following events are identified as potential PEs representing the release of hazardous chemicals:

- Chemical solution spill in packaging box or during transfer to the HCF high bay.
- Nitric acid solution spill in dissolver box.
- Chemical solution spill in purification activities.

The chemical exposure to a member of the public from a nitric acid spill that is not immediately cleaned up is calculated using the 95th percentile meteorological conditions at the EIPC site. The Protective Action Criteria (PAC) from Tables Rev. 29a of the DOE Chemicals of Concern and Associated Chemical Information (DOE, 2018) for nitric acid are 0.16 parts per million (ppm), 24 ppm, and 92 ppm for PAC-1, PAC-2, and PAC-3. The results from the analysis indicate that the chemical dose or concentration for the MEI is below the PAC-1, PAC-2, and PAC-3 levels.

Releases of hazardous chemicals are mitigated by staff trained to properly respond to a chemical spill in the HCF, including the dissolver box and processing box. The volumes of the

chemical solutions used in the processing kits are small, and cleanup of a spill is done by using spill kits and neutralizing absorbers located throughout the facility. The chemical exposure from a nitric acid spill in the HCF not immediately cleaned up is less than the U.S. OSHA airborne permissible exposure limit for a worker over an 8-hr. work shift.

19.4.12 NOT USED

19.4.13 CUMULATIVE EFFECTS

This section discusses cumulative impacts associated with the construction, operation, and eventual decommissioning of the EIPC. The term “cumulative impact” is defined in the Council on Environmental Quality regulations implementing the National Environmental Policy Act (40 CFR 1508.1) as follows:

> Effects on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.

Per the requirements of NUREG-1537, actions considered in the cumulative impact analyses include proposed and continuing actions that are conducted, regulated, or approved by a federal agency or a non-federal entity. The cumulative impacts analysis considers all actions, however minor, because impacts from individually minor actions may be significant when considered collectively over time.

The affected environment for the EIPC is described in Section 19.3. Impacts associated with construction, operation, and decommissioning of the EIPC are described in Sections 19.4.1 through 19.4.11. The resource areas evaluated for cumulative impacts are generally the same as those evaluated in the sections identified above.

Relevant past, present, and reasonably foreseeable future actions potentially impacting and impacted by the EIPC are identified in Table 19.4.13-1. The analysis of potential cumulative impacts is based on publicly available information about existing and proposed projects, publicly available NRC documents, and general knowledge of the conditions in the region. Only past, present, and reasonably foreseeable future actions within the identified geographic scope for an individual resource area are described in the next subsections; however, a narrower geographic scope of analysis may be further delineated for each resource area, as necessary.

19.4.13.1 Land Use and Visual Resources

The description of the affected environment in Section 19.3.1 serves as a baseline for the land use and visual cumulative impact assessment. Therefore, the geographic area of impact (GAI) for evaluation of cumulative effects on land use and visual resources is the same as that used in Section 19.3.1, namely the 245.6 ac. (99.4 ha) of land within the project boundary and the associated 5-mi. (8-km) region surrounding the site.

Table 19.4.13-1 identifies all past, present, and reasonably foreseeable future actions within the GAI identified above for assessment of impacts to land use and visual resources. As discussed in Section 19.4.1, construction, operations, and decommissioning impacts from the EIPC to land use and on visual resources are SMALL.

19.4.13.1.1 Land Use

As described in Section 19.3.1, the project site is vacant and land cover is almost entirely scrubland/shrubland with a small amount of developed, low-intensity land use. Approximately

98 percent of the project site is designated as prime farmland of statewide importance. Additionally, the off-site utility corridor traverses portions of New Mexico State Trust Land.

Land use within the 5-mi. (8-km) region of the EIPC has been altered through construction and operation of nuclear and NRC-licensed facilities, oil, gas exploration, and materials mining, housing development, and landfills and waste disposal sites. These facilities include the URENCO Facility, WCS Facility, Lea County Landfill, Permian Basin Materials, Sundance Services, Wallach Concrete, and various oil and gas mining operations. These facilities have resulted in development of vacant land and conversion of prime farmland and farmland of statewide importance, as well as other agricultural land resources.

Foreseeable future actions include development of the C.K. Disposal E&P Landfill and Processing Facility (C.K. Disposal Facility), Interim Storage Partners (ISP) expansion, housing development in accordance with the Lea County Comprehensive Plan, and expansions of oil, gas, and materials mining, which also impacts available land and agricultural resources within the 5-mi. (8-km) region. The landfills, future housing development, and oil, gas, and materials mining would occur on land currently designated for these uses, and therefore the impact to land use are minimal. Impacts to New Mexico State Trust Land for the off-site utility corridor are minor as the area has been heavily disturbed for previous industrial and utility use. The minor loss of on-site agricultural lands, including prime farmland of statewide importance, and the subsequent loss of potential agricultural land to other future industrial facilities and new development, is minor when compared with available agricultural land and land designated as prime farmland remaining within the region (see Table 19.4.1-1).

Overall, impacts of these past and ongoing actions in conjunction with the effects of the proposed action and other reasonably foreseeable future actions on land use are MODERATE.

Future development of the EIPC has the potential to impact land use on the EIPC site. As described above, land use impacts resulting from construction, operation, and decommissioning of the EIPC are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to land use is SMALL and would not be a significant contributor to the MODERATE cumulative impact.

19.4.13.1.2 Visual Resources

The EIPC is located almost entirely on scrubland/shrubland, and the project site has no existing architectural features, established structures, or natural barriers, screens, or buffers. The visual setting of the project site is generally flat and uniform in landform with low diversity and a low visual quality rating, as detailed in Subsection 19.3.1.2. Consequently, construction of the EIPC and associated structures alters on-site conditions and partially obstructs the views of the existing landscape but would not significantly alter the landscape or scenic quality.

The 5-mi. (8-km) region houses various oil, gas, and materials mining operations, NRC-licensed facilities, and urban development in the City of Eunice (see Subsection 19.3.1.1). These existing facilities alter the viewshed of the region. However, as the region is of low scenic quality, these impacts do not significantly alter the visual setting. Expansion or development of future facilities would have an additional impact to the visual and scenic resources due to increased vehicle traffic, land disturbances, landscape changes, heavy equipment use, and construction, operation, and maintenance of project facilities and infrastructure.

Impacts of these past and ongoing actions in conjunction with the effects of the proposed action and other reasonably foreseeable future actions on visual resources are SMALL.

Future development of the EIPC has the potential to impact visual resources. As described above, visual impacts resulting from construction, operation, and decommissioning of the EIPC are SMALL. Because the proposed action would not result in a noticeable change to visual resources, the impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC on visual resources would not be a significant contributor to the SMALL cumulative impact.

19.4.13.2 Air Quality and Noise

19.4.13.2.1 Air Quality

Subsection 19.3.2.1 serves as a baseline for the air quality cumulative impact assessment. Table 19.4.2-3 provides estimates for air pollutants from all on-site sources, including standby diesel generators, FWP, and cooling towers.

Air quality impacts resulting from construction, as described in Subsection 19.4.2.1.1, are SMALL as emissions are controlled at the source when possible, the project is located a significant distance from the public, and regulatory permits would be obtained as deemed required and appropriate.

Air quality impacts stemming from operations, as described in Subsection 19.4.2.1.2, are SMALL, as would air quality impacts during decommissioning as described in Subsection 19.4.2.1.2.5.

Criteria Pollutants

Construction and decommissioning of the EIPC are similar in nature and cause localized air emission impacts which includes fugitive dust emissions from the actual construction of the facility and exhaust air emissions from increased traffic and use of diesel engines used by the heavy construction equipment that is brought on-site. Should any other local construction projects be ongoing at the time of the EIPC construction, air emission impacts from all ongoing projects would be cumulative. However, as the impacts to the air quality during construction are expected to be minor, localized, and short term, the impacts would be SMALL.

Operation of solely the EIPC results in emissions from the site which are estimated to be slightly more than 200 tons (181 tonnes) per year, as shown in Table 19.4.2-3, for which air quality modeling has been completed. The air quality modeling results from the on-site new emissions sources were compared to the NAAQS and NMAAQS and the results concluded that the EIPC does not cause or contribute to an exceedance of the NAAQS and NMAAQS.

Concurrent operations of additional local facilities within 6 mi. (9.7 km) of the EIPC include six facilities that are currently in operation and an additional two facilities anticipated to operate in the future, for a total of eight facilities with future operations. The majority of the facilities listed in Table 19.4.13-1 may contribute to cumulative impacts to regional and local air quality during operations. New Mexico has measures in place to enforce the Federal CAA and has also enacted the Environmental Improvement Act and Air Quality Control Act, to protect public health. The principal (criteria) pollutants for which NAAQS have been set are CO, NO_2, lead, SO_2, PM_{10}, $PM_{2.5}$, and O_3. One or more averaging times are associated with each pollutant for

which the standard must be attained. Therefore, as with construction-related air permits, the NMED AQB would also review the operational facilities permits for air emissions, ensuring that air quality in the region remains in attainment. Thus, the cumulative impacts on criteria pollutants are expected to be SMALL.

Greenhouse Gas Emissions

The cumulative impacts of a single or combination of GHG emission sources must be placed in geographic context, considering the following factors:

- The environmental impact should be assessed on a global rather than local or regional basis.
- The effect is not sensitive to the location of the emission release point.
- The magnitudes of individual GHG sources related to human activity, no matter how large compared to other sources, are small when compared to the total mass of GHGs in the atmosphere.
- The total number and variety of GHG sources is extremely large and the sources are ubiquitous.

GHG emissions associated with building, operating, and decommissioning the new facility are discussed in Subsection 19.4.2.1.2.3. As noted in Subsection 19.4.2.1.2.3, Eden will develop a comprehensive program to avoid and control GHG emissions associated with the EIPC. At a minimum the program includes the following:

- Developing a GHG emission inventory.
- Investigating and implementing methods for avoiding or controlling the GHG emissions identified in the inventory.
- Encouraging carpooling or other measures to minimize GHG emissions due to vehicle traffic during construction and operation of the EIPC.
- Conducting periodic audits of GHG control procedures and implementing corrective actions, when necessary.

Evaluation of cumulative impacts of GHG emissions requires the use of a global climate model. A synthesis of the results of numerous climate modeling studies are presented in the report from Karl, et al. (Karl et al., 2009). The cumulative impacts of global GHG emissions as presented in the report are the appropriate basis for evaluation of cumulative impacts with regards to the EIPC. The report concludes that climate changes are underway in the United States as part of the global climate and that these changes are projected to grow. While noticeable, none of the changes result in a destabilization of the global climate. In 2010 the USEPA issued the CO_2 Tailoring Rule (75 Federal Register 31514), which stated that GHG emissions are factors in Prevention of Significant Deterioration and Title V permitting and reporting. This revised permitting criterion indicates the need to regulate CO_2 and other GHGs from major emission sources. GHG emissions from individual stationary sources and, cumulatively, from multiple sources can contribute to national and global climate change. Given the relatively low emissions from the EIPC in comparison to total global emissions, cumulative impacts of the proposed facility are SMALL. Furthermore, the cumulative impacts of GHG emissions would still be the same at the national and global scale without the GHG emissions of the proposed EIPC.

19.4.13.2.2 Noise

The description of the affected environment in Subsection 19.3.2.2 serves as a baseline for the noise cumulative impact assessment. The GAI for evaluation of cumulative effects from noise emissions includes the land within the site boundary and the associated 5-mi. (8-km) region surrounding the site. Noise impacts resulting from construction, operation, and decommissioning of the EIPC are discussed in Subsection 19.4.2.2. and are SMALL.

As described in Subsection 19.4.2.2, noise levels from construction equipment are expected to attenuate rapidly with distance and, therefore, do not significantly impact the closest noise receptor, which is located 1.7 mi. (2.7 km) to the west of the project site center. At this distance, construction noise attenuates to levels below both Lea County's nighttime limit and the USEPA's recommended limits. External noise emissions from the EIPC during operations are primarily limited by the walls of the facility and other physical barriers. The outdoor MDCTs produce noise, which, based on straight-line noise attenuation, falls below Lea County's nighttime noise limit. Noise levels are also impacted by increases in traffic volume during construction, operations, and decommissioning; however, projected increase in traffic volumes during these phases would not result in perceptible increase over existing noise levels (see Subsection 19.4.2.2).

As shown in Table 19.4.13-1, proposed construction projects and existing and proposed operational facilities are located in the GAI. The closest noise-generating operational facility is located approximately 1.3 mi. (2.1 km) north of the EIPC site center. Proposed future actions include the C.K. Disposal Facility located 1.1 mi. (1.8 km) east of the EIPC site center, ISP expansion at the WCS site, housing development, and future oil, gas, and materials mining. These facilities are located to the north and east of the EIPC and away from major population centers and sensitive receptors. Noise levels are also impacted by increases in traffic volume during both construction, operation, and decommissioning of the EIPC and other projects in the GAI. However, traffic associated with these facilities would be dispersed and is not expected to be significantly higher than current traffic levels on individual roadways.

Overall, the impact on noise levels associated with the past and ongoing actions together with noise levels generated by the effects of the development of the EIPC and other reasonably foreseeable future actions are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to noise is SMALL and would not be a significant contributor to the SMALL cumulative impact.

19.4.13.3 Geologic Environment

Section 19.3.3 describes the affected environment and serves as a baseline for the geologic environment cumulative impact assessment. The GAI for evaluation of cumulative effects is the same as that used in Section 19.4.3 and is limited to the land within the EIPC site boundary and the associated 5-mi. (8-km) region surrounding the site. Additionally, as discussed in Section 19.4.3, construction, operations, and decommissioning impacts from the EIPC on the geologic environment, including both soils and geology, are SMALL.

Table 19.4.13-1 identifies the recent past, present, and reasonably foreseeable future actions located within the GAI. These planned actions would be constructed outside the limits of the project site boundary; therefore, cumulative impacts are limited to indirect impacts to the region. Within the GAI, nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities are ongoing and are projected to

continue. The development of these facilities required clearing of vegetation, excavation and soil removal, and discharge of stormwater runoff. These impacts can also disturb subsurface bedrock and lead to soil erosion; however, these activities are likely subject to state and federal requirements for monitoring and mitigation. Oil, gas, and materials mining may result in induced seismicity, sinkholes, and general subsidence throughout the region from the extraction process. Proposed actions within the region, including the C.K. Disposal Facility and the ISP expansion, may further contribute to localized impacts to soil and geology through the mechanisms identified above. Overall, the impacts of these past, present, and reasonably foreseeable future actions in conjunction with the effects of the development of the EIPC on soils and geology are MODERATE.

As described above, impacts to geology and soils resulting from construction, operation, and decommissioning of the EIPC are SMALL. Additionally, the impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC on geology and soils is SMALL and would not be a significant contributor to the MODERATE cumulative impact.

19.4.13.4 Water Resources

Section 19.3.4 serves as a baseline for the water resources cumulative impact assessment. The GAI for evaluation of cumulative effects on water resources is described in Section 19.4.4 and is limited to the land within the project site boundary and the associated 5-mi. (8-km) region surrounding the project site. As discussed in Section 19.4.4, impacts from construction, operation, and decommissioning of the EIPC to water resources are SMALL.

Table 19.4.13-1 identifies recent past, present, and reasonably foreseeable future actions within the GAI that can be assessed to determine cumulative effects on water resources.

19.4.13.4.1 Hydrology

The evaporation pond located on-site is designed to not overflow during a PMP event; therefore, there are no direct impacts to streams or water bodies. BMPs, such as those required in the SWPPP, stormwater runoff design controls, and the on-site stormwater retention pond mitigate indirect impacts from the EIPC to surface water hydrology.

Within the GAI, nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities are ongoing and are projected to continue. Additionally, the C.K. Disposal Facility, ISP expansion, additional housing development, and additional oil, gas, and materials mining activities are foreseeable future actions within the GAI. Impacts from these activities are related to surface water runoff and leaks or spills from equipment and from active or plugged wells. Overall, impacts of past and ongoing actions in conjunction with the effects of the EIPC project and other reasonably foreseeable future actions to hydrology are SMALL.

19.4.13.4.2 Water Use

As described in Subsection 19.3.4.2.3, the City of Eunice municipal water supply draws water from the High Plains Aquifer within the Lea County UWB. All water used at the EIPC during construction, operations, and decommissioning is obtained from the Eunice municipal water supply and normal sanitary wastewater discharges are sent directly to the Eunice wastewater system. Cooling tower blowdown and liquid discharge from the LECS is routed to an

evaporation pond. LECS liquid discharge is monitored and treated to remove radioisotopes prior to discharge to the evaporation pond. Additionally, there is minimal release of water from the facility to the adjacent environment that impacts surface water systems.

Ongoing actions within the GAI include nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities. These facilities impact groundwater through consumptive use of water. Other foreseeable future actions require use of the regional water supply and wastewater treatment systems. However, at this time, no upgrades to the Eunice water supply system are required. Nevertheless, given the potential demands on water use associated with past and ongoing actions in conjunction with the effects of the proposed action and other reasonably foreseeable future actions, the cumulative effect on water use is MODERATE.

19.4.13.4.3 Water Quality

Indirect impacts to surface water quality are related to stormwater and pollutant runoff within the project area. As detailed in Subsection 19.4.4.3, potential indirect surface water quality impacts from construction and decommissioning of the EIPC are similar to those from construction and decommissioning of any typical industrial or commercial facility in the area and are minor. Future development in the 5-mi. (8-km) region may also contribute to surface water runoff; however, minimal surface water features exist in the 5-mi. (8-km) region, and it is anticipated that mitigation measures required by state and federal regulations regarding water quality would be utilized.

Indirect impacts to groundwater quality can occur during construction, operation, and/or decommissioning of the EIPC. These impacts are related to spills from vehicles, equipment, or storage areas that penetrate hard surfaces or are accidentally released to pervious surfaces and migrate to groundwater prior to detection and remediation. BMPs to mitigate incidental spills include abiding by the SPCC plan (see Subsection 19.4.4.3). Ongoing and foreseeable future actions within the GAI include operation of nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities. These facilities have the potential to cause groundwater contamination, particularly oil and gas mining operations, through improperly plugged or cased wells and through incidental spills from equipment. Overall, impacts of past and ongoing actions in conjunction with the effects of the EIPC project and other reasonably foreseeable future actions to water quality are SMALL.

19.4.13.4.4 Summary of Water Resources Cumulative Impacts

Overall, given adherence to BMPs and other mitigative measures, impacts of past and ongoing actions in conjunction with the effects of the EIPC project and other reasonably foreseeable future actions to water quality and hydrology are minor. However, given the potential future demands on water use associated with past and ongoing actions in conjunction with the effects of the proposed action, the cumulative effect on water resources is MODERATE.

As described above, impacts to water resources from construction, operation and decommissioning of the EIPC are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to water quality are minor and would not be a significant contributor to the MODERATE cumulative impact.

19.4.13.5 Ecological Resources

The baseline for the ecological resource cumulative impact assessment is described in Section 19.3.5. The GAI for evaluation of cumulative effects to ecological resources is the same as that used in Section 19.4.5 and is limited to the land within the project site boundary and the associated 5-mi. (8-km) region surrounding the project site. As discussed in Section 19.4.5, impacts from construction, operation, and decommissioning of the EIPC to terrestrial communities, aquatic communities, and protected species are SMALL.

Terrestrial community resources could be affected by the EIPC through direct construction impacts. Construction of the EIPC permanently converts 55.7 ac. (22.5 ha) of scrubland/shrubland habitat to industrial facilities (see Section 19.4.5). Subsection 19.3.5.11 states that no state- or federal-listed plant species occur within Lea County, and the project site and region do not include mapped critical habitat for any listed endangered species.

Activities in the region evaluated for cumulative impacts include nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities. The cumulative effect of these facilities has had historical impacts to ecology due to habitat loss and segmentation, stresses on wildlife, and direct and indirect wildlife mortalities. Future activities, such as the C.K. Disposal Facility, expansion of oil, gas, and material mining and production activities, ISP expansion, and housing development would also impact wildlife through habitat loss and fragmentation and associated stresses and mortalities.

As described in Subsection 19.3.5.5, no permanent surface water features are present within or near the EIPC project site. Additionally, none of the surface water features within the 5-mi. (8-km) region nor the on-site site evaporation pond support aquatic communities. Further, Subsection 19.3.5.6 details that wetlands are not present within the EIPC project site and that only 31.2 ac. (12.6 ha) of emergent wetlands and 95.7 ac. (38.7 ha) of scrub/shrub wetlands exist within the 5-mi. (8-km) project region.

Development of facilities within the GAI has resulted in the loss of wildlife and habitat. Impacts of these past and ongoing actions together with the effects of the construction, operation, and decommissioning of the EIPC and other reasonably foreseeable future actions on ecological resources are MODERATE.

Impacts associated with the construction, operation, and decommissioning of the EIPC are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operations, and decommissioning of the EIPC on ecological resources is minor and would not be a significant contributor to the MODERATE cumulative impact.

19.4.13.6 Historic and Cultural Resources

The affected environment described in Section 19.3.6 serves as the baseline for the historic and cultural resources cumulative impact assessment. The GAI for cumulative effects evaluation on historic and cultural resources is the direct APE, consisting of the 245.6 ac. (99.4 ha) of land within the project boundary and an indirect APE of the 0.3-mi. (0.5-km) radius extending from the proposed project boundary (see Section 19.4.6).

As described in Section 19.3.6, two previous cultural resource surveys have been completed within the 0.3-mi. (0.5-km) radius of the project site, neither of which identified cultural resources. No archaeological sites have been recorded within or immediately adjacent to the

project site prior to the Phase I Environmental Site Assessment (performed by NV5 in 2020) of the EIPC site, nor are any listed properties within or near the project site. Further, as described in Section 19.4.6, a cultural resource survey identified six isolated occurrences of archaeological and historic resources within or immediately adjacent to the EIPC site. All the occurrences were determined ineligible for inclusion on the NRHP and no further work was recommended. Based on the absence of historic properties and archaeological sites on the project site and the absence of SRCP and NRHP-listed properties near the project site, the impacts to historic and archaeological resources from construction, operation, and decommissioning of the EIPC are SMALL.

Impacts to historic and cultural resources in the GAI result from land-disturbing activities related to development of existing facilities as well as construction of reasonably foreseeable future actions. As future actions are constructed, it is anticipated that activities associated with surface-disturbing activities would be surveyed for historic and cultural resources as appropriate. Due to the reliance on federal and state regulations to protect cultural and historic resources, impacts of past and ongoing actions in conjunction with the effects of construction, operation, and decommissioning of the EIPC to historic and cultural resources are SMALL.

Impacts to historic and cultural resources associated with construction, operation, and decommissioning of the EIPC are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to historic and cultural resources is minor and would not be a significant contributor to the SMALL cumulative impact.

19.4.13.7 Socioeconomic Environment

The description of the affected environment in Section 19.3.7 serves as a baseline for the socioeconomic cumulative impact assessment. The GAI for evaluation of cumulative effects is the same as that used in Section 19.4.7 and includes the 245.6 ac. (99.4 ha) of land within the project boundary and the three-county ROI comprising Lea County, NM, Andrews County, TX, and Gaines County, TX. As described in Subsection 19.4.7.1, impacts from construction, operations, and decommissioning to socioeconomic conditions is SMALL. And as discussed in Subsection 19.4.7.2, impacts from construction, operations, and decommissioning to traffic conditions are SMALL.

Table 19.4.13-1 details recent past, present, and reasonably foreseeable future actions within the GAI. As related to evaluation of cumulative impact analysis, only those actions within the three-county ROI are identified as relevant to this socioeconomic analysis.

19.4.13.7.1 Water Supply and Water Treatment

As described in Subsection 19.4.7.1, the EIPC utilizes potable water from the City of Eunice and sends normal sanitary water for treatment to the Eunice treatment facility. Blowdown from cooling and drainage from the LECS is routed to the evaporation pond. Upgrades to the Eunice water supply system or sanitary wastewater treatment systems are not anticipated. Future infrastructure and development in and around Eunice would place additional demands on Eunice’s water supply and water treatment systems. However, as described above, impacts from the EIPC to the water supply and sanitary water treatment systems are SMALL. Future actions, such as housing development, the C.K. Disposal Facility, and oil, gas, and materials mining, require potable water and likely utilize wastewater systems.

19.4.13.7.2 Tax Base

Development of the EIPC facilitates the creation of new jobs and industrial spending on materials and supplies. These jobs support the diversification of the economy and increase payroll spent in the ROI. As described in Subsection 19.4.7.1, the total payroll generated and associated taxable spending benefit Lea County, NM, but are small in comparison with the cumulative 2021 income. Development of the C.K. Disposal Facility and ISP expansion, increase in housing within Lea County, and future oil, gas, and materials mining operations would create additional jobs and new infrastructure, but are not anticipated to significantly impact tax revenues within the ROI.

19.4.13.7.3 Population

As described in in Subsection 19.4.7.1, the anticipated in-migrating workforce and their families during both the construction and operations phases are estimated to result in less than a 0.2 percent increase to total population within the ROI. As decommissioning impacts are anticipated to be smaller than construction, decommissioning impacts are bound by the construction impacts. Future actions, including the C.K. Disposal Facility and ISP expansion, increase in housing within Lea County, and future oil, gas, and materials mining operations in the ROI would create new jobs and bring in-migrating workers. However, as populations within the ROI are anticipated to increase in the future (see Table 19.3.7-2), it is not anticipated that reasonably foreseeable future actions would significantly alter populations within the ROI.

19.4.13.7.4 Transportation

Subsection 19.4.7.2 details that deceleration lanes for eastbound and westbound traffic are needed to allow for right and left turns into the EIPC, which may require widening a short segment of NM-176. No other modification to the local transportation infrastructure is necessary to accommodate traffic related to construction, operation, and decommissioning at the EIPC site. At this time, it is unlikely that any of the identified reasonably foreseeable future actions would overlap with construction-related traffic at the EIPC.

During operation of the EIPC, workers at the EIPC, URENCO facility, WCS facility, Sundance Materials, and Wallach Concrete are likely to utilize NM-176 during their commutes. However, all LOS ratings on these roadways are determined to be acceptable (LOS C or better) for the intersections and individual movements within the intersections closest to the EIPC (see Figure 19.4.7-1) for the near future (2032) and meet the requirements of the NMDOT's minimum acceptable LOS standards (see Subsection 19.4.7.2). Future actions, including the C.K. Disposal Facility, ISP expansion, increase in housing within Lea County, and future oil, gas, and materials mining operations, would impact regional transportation. It is likely that construction and operations workers would utilize NM-176 for access to the C.K. Disposal Facility and ISP expansion. However, several existing industrial and processing facilities are located along NM-176.

19.4.13.7.5 Summary of Socioeconomic Cumulative Impacts

Overall, impacts of these past and ongoing actions in conjunction with the effects of the construction, operation, and decommissioning of the EIPC, together with other reasonably foreseeable future actions, to socioeconomic resources are SMALL to MODERATE.

As described above, socioeconomic impacts associated with construction, operation, and decommissioning of the EIPC are SMALL. Additionally, the impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to socioeconomic impacts is minor and would not be a significant contributor to the SMALL to MODERATE cumulative impact.

19.4.13.8 Human Health

Section 19.4.8 describes the GAI for evaluation of cumulative effects on human health, which includes the land within the site boundary and the associated 5-mi. (8-km) region surrounding the site. Table 19.4.13-1 details the past, present, and reasonably foreseeable future actions within the GAI for cumulative impact analysis. Relevant actions that are considered in these cumulative effects analysis are limited to the facilities and actions within a 5-mi. (8-km) region.

19.4.13.8.1 Nonradiological Impacts

Construction of the EIPC includes potential hazards to workers typical of any construction site. Potential nonradiological waste sources pertaining to operation of the EIPC are associated with emissions, discharges, and waste associated with chemical processes within the facility as well as accidental spills/releases. Control systems are in place for the EIPC in accordance with New Mexico Environmental Management Regulations and local requirements to minimize potential exposure to the public. These controls include conveyance of all wastewater to appropriate approved wastewater treatment facilities, and the on-site evaporation pond, implementation of SPCC plans, and air emission controls, as appropriate. Therefore, nonradiological impacts to human health are SMALL.

Ongoing and future activities within the GAI include nuclear and NRC-licensed facilities, landfills and waste disposal sites, housing development, and oil, gas, and materials mining activities, which would contribute to cumulative health impacts to the public and construction workers. Control systems and state and federal air permitting coupled with the use of BMPs would help mitigate these impacts. Therefore, the cumulative impact associated with past, ongoing, and other reasonably foreseeable future actions in conjunction with the effects of the construction, operation, and decommissioning of the EIPC on human health are SMALL.

As described above, impacts resulting from construction, operation, and decommissioning of the EIPC are SMALL. Additionally, impact of the incremental contribution of the NRC-authorized activities related to construction, operation, and decommissioning of the EIPC to human health is SMALL and would not be a significant contributor to the SMALL cumulative impact.

19.4.13.8.2 Radiological Impacts

The proposed EIPC anticipates releases of small quantities of radionuclides to the environment. The estimated TEDE doses from the RF and HCF are discussed in Subsections 19.4.8.2.4.1 and 19.4.8.2.4.2, respectively. The estimated dose from the evaporation pond is expected to be within the regulatory limits. As such, the radiological impacts to members of the public due to operation of the EIPC site are SMALL.

For analysis of cumulative impacts, the geographic area of interest considered was 50 mi. beyond the site boundary. Table 19.4.13-1 summarizes past, present, and future projects and actions that could contribute to cumulative effects. Those listed that have a potential to contribute to cumulative radiation exposures include the existing URENCO National Enrichment

Facility, WCS Consolidated Interim Storage Facility (CISF), the proposed International Isotopes Fluorine Products Inc. (IIFP) – Fluorine Extraction Process and Depleted Uranium Deconversion Plant, the Holtec Hi-Store CISF, and the Waste Isolation Pilot Plant (WIPP).

The URENCO enrichment facility, WCS CISF, IIFP, Holtec Hi-Store CISF, and WIPP have a proposed cumulative dose to a MEI of 2.2E-01 millisieverts (mSv)/year (2.2E-011 mrem/year) (NRC, 2015), 4.3E-04 mSv/year (4.3E-02 mrem/year) (WCS, 2016), 1.4E-04 mSv/year (1.4E-02 mrem/year) (NUREG-2113, Environmental Impact Statement for the Proposed Fluorine Extraction Process and Depleted Uranium Deconversion Plant in Lea County, New Mexico), 2.5E-02 mSv/year (2.5E+00 mrem/year) (Holtec, 2019), and 2.4E-03 mSv/year (2.4E-01 mrem/year) (DOE, 2015), respectively. Therefore, the annual cumulative doses from sources near the EIPC are less than 100 mrem/year.

In addition, the Permian Regional Medical Center, Seminole Hospital District, and Nor-Lea Hospital District provide imaging services to patients that include Magnetic Resonance Imaging (MRI) and mammography services, and nuclear medicine. Doses from radiological exposure to the public from these facilities are negligible. Therefore, cumulative impacts to radiological health are SMALL.

As described in Section 19.4.10, the effect of transportation of radioactive material from the EIPC on the public is SMALL. The shipment of radioactive material for the EIPC and the sources near the EIPC contribute to the cumulative impact of radioactive material production, storage, utilization, and disposal for all facilities in the United States that utilize radioactive material. The cumulative impacts of the transportation of radioactive materials for the existing facilities in the region, including the Permian Regional Medical Center, Seminole Hospital District, and Nor-Lea Hospital District are SMALL and the impacts from the addition of the EIPC do not change that conclusion. Therefore, cumulative effects on transportation of nuclear material from the addition of the EIPC are SMALL.

19.4.13.9 Conclusion

Potential cumulative impacts resulting from construction, operation, and decommissioning of the EIPC together with other past, present, and reasonably foreseeable future actions within the GAI are reviewed. The specific resources that could be affected by the EIPC and other past, present, and reasonably foreseeable actions in the GAI are assessed. The cumulative impacts for most of the resource areas would be SMALL to MODERATE. However, the incremental impact of the construction, operation, and decommissioning of the EIPC would not be a significant contributor to the cumulative impact.

Table 19.4.13-1
(Sheet 1 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Mining, Oil, and Gas Exploration				
Wallach Concrete, Inc.	Facility produces ready-mix concrete mixture; also houses a sand/aggregate quarry.	Lea County, NM	0.83 mi.	Present, Future
Permian Basin Materials	Facility develops aggregate and ready-mix to West Texas and southeastern New Mexico.	Lea County, NM	1.44 mi.	Present, Future
Ochoa Sulphate of Potash (SOP)	SOP is a fertilizer production operation that uses room-and-pillar mining to extract polyhalite/sulfate potash from the Rustler Formation.	Lea County, NM	28.16 mi.	Present, Future
Oil and Gas Mining	General oil and gas mining throughout southeastern New Mexico. No known use of radioactive material in the local mining industry.	Lea County and Eddy County, NM	Variable	Present, Future
Nuclear or NRC-Licensed Facilities				
URENCO — UUSA National Enrichment Facility — Louisiana Energy Services LLC	Uranium enrichment facility producing enriched uranium for commercial nuclear power reactors. Began operation in 2010, with a 30-year license from the NRC. Environmental impacts assessed during the licensing process are primarily deemed to be small, with the exception of the positive impact of increased tax revenue.	Lea County, NM	0.81 mi.	Present, Future
URENCO — UUSA National Enrichment Facility Capacity Expansion — Louisiana Energy Services LLC	The URENCO expansion to produce Uranium from 3 million to 10 million separative work units per year is evaluated as a present action. Based on the expansion project's Environmental Assessment, the proposed expansion was to occur between 2012 and 2020 with operations assumed to begin subsequently. As a result, this action is considered a present action within this ER.	Lea County, NM	0.81 mi.	Present, Future

Table 19.4.13-1
(Sheet 2 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Waste Control Specialists (WCS) Facility	WCS operates a treatment, storage, and disposal facility authorized to dispose of Class A, B, and C low-level radioactive waste.	Andrews County, TX	2.20 mi.	Present, Future
WCS Facility Expansion by Interim Storage Partners (ISP)	WCS and Orano CIS LLC partnered to form ISP and submitted a license for construction and operation of a consolidated interim storage facility at the existing WCS site for 5500 short tons. NRC has granted a license, and construction has not yet begun.	Andrews County, TX	3 mi.	Future

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Table 19.4.13-1
(Sheet 3 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Nuclear or NRC-Licensed Facilities (continued)				
International Isotopes Fluorine Products Inc. (IIFP)	Facility that plans to deconvert depleted uranium hexafluoride into fluoride products for commercial resale and uranium oxides for disposal. NRC issued a construction and operation license in 2012. No construction activities have occurred to date.	Lea County, NM	23.59 mi.	Future
CISF — Holtec Hi-Store Consolidated Interim Storage	Centralized facility for storage of used nuclear fuel and high-level radioactive waste until such time that a permanent solution is available.	Lea County, NM	37.50 mi.	Present, Future
Waste Isolation Pilot Plant (WIPP)	WIPP is a permanent disposal facility for transuranic waste. It is the only U.S. deep geological repository and is located 2150 ft. underground in large panels mined out of salt rock beds. The facility currently consists of 8 panels, with two more panels planned.	Eddy County, NM	40.60 mi.	Present, Future
Gnome-Coach Site	Site of underground nuclear test in 1961. Since 1963, the U.S. DOE has performed cleanup actions at the site through a Voluntary Remediation Agreement with the State of New Mexico. In 2015, a Conditional Certificate of Completion for the site surface cleanup was granted, certifying that all surface remediation had been completed in accordance with the State of New Mexico requirements and specifying long-term management requirements. Subsurface contamination remains and subsurface excavation is limited. The DOE currently monitors groundwater at the site.	Eddy County, NM	46.14 mi.	Past

Table 19.4.13-1
(Sheet 4 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Wind, Solar, and Other Energy Projects				
Jumbo Hill Wind Project	Wind turbine facility that produces 160 MW of power annually.	Andrews County, TX	6.63 mi.	Present, Future
Gaines Cavern Wind Project	Wind turbine facility that produces 2 MW of power annually.	Gaines County, TX	17.75 mi.	Present, Future
Exelon Wildcat Wind Project	Wind turbine facility that produces 27 MW of power annually.	Lea County, NM	37.67 mi.	Present, Future
Solar Power Plants: SPS1 Dollarhide, SPS2 Jal, SPS3 Lea, SPS4 Monument, Middle Daisy	Various solar power plants in Eddy County and Lea County, NM.	Eddy County, and Lea County, NM	13.26 – 40.83 mi.	Present, Future
Oso Grande Wind Project	61 turbines with an expected output to power over 100,000 homes.	Chaves County, Eddy County, and Lea County, NM	49.79 mi.	Present, Future
Xcel Energy Power for the Plain Project	Transmission line and substation upgrade project throughout New Mexico and Texas.	Eastern New Mexico and Western Texas	Variable throughout the Region	Past
Double E Pipeline, LLC	Operation of approximately 135 combined miles of varying diameter trunk lines and lateral pipeline connecting the Delaware Basin production areas in New Mexico and Texas to the Waha Hub.	Eddy County, NM and Loving, Ward, Reeves, and Pecos counties, TX	Variable throughout the Region	Present, Future

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Table 19.4.13-1
(Sheet 5 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Landfills and Waste Disposal Sites				
C.K. Disposal E&P Landfill and Processing Facility	Surface waste management facility for oilfield waste processing and disposal services. The proposed tract of land encompasses approximately 316.97 ac.	Lea County, NM	0.64 mi.	Future
Sundance Services Industries (Parabo Facility)	Sundance Service is a full-service oilfield waste disposal facility.	Lea County, NM	1.13 mi.	Present, Future
Lea County Sanitary Waste Landfill	Lea County Sanitary Waste Landfill annually receives: 90.7 metric tons each of treated formerly characteristic hazardous waste, offal, sludge, and spill waste; 454 metric tons each of industrial solid waste, petroleum-contaminated soils, and other solid waste; and up to 2268 metric tons of asbestos waste.	Lea County, NM	1.22 mi.	Present, Future
Milestone Environmental Services facility	10-ac. oilfield waste facility that operates an underground injection control class II disposal well for the injection of slurry into the subsurface. Permit received in 2021.	Lea County, NM	23.68 mi.	Present, Future
OWL Surface Waste Management Facility	A 540-ac. oil and gas landfill, capable of handling over 400 loads per day of mud, cuttings, and other solid wastes from oil and gas operations.	Lea County, NM	29.38 mi.	Present, Future
Lea Land, LLC	Oilfield waste landfarm that provides waste management services in support of the oilfield industry. Issued a permit in 2020 to expand the site by approximately 100 ac. to be set aside for permanent disposal of exempt and nonhazardous oilfield waste.	Eddy County, NM	40.83 mi.	Present, Future

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Table 19.4.13-1
(Sheet 6 of 6)
Past, Present, or Reasonably Foreseeable Future Actions within the 50-Mi. (80-Km) Region

Action	Description	Location	Distance from the Project Boundary	Time Frame
Housing Development				
Lea County Housing Development	Lea County's Comprehensive Plan documents increasing housing by 2025.	Lea County, NM	Variable throughout Lea County.	Future
Medical Facilities				
Permian Regional Medical Center	Regional hospital with radiology department, offering imaging services including CT scans, x-rays, biopsies, mammograms, bone density, MRI services, and nuclear medicine.	Gaines County, TX	32.33 mi.	Present, Future
Seminole Hospital District	Regional hospital with radiology department, offering imaging services including x-rays, fluoroscopy, computed tomography, bone density, 3D mammography, and MRI services.	Andrews County, TX	32.52 mi.	Present, Future
Nor-Lea Hospital District	Regional hospital with radiology department, offering imaging services including x-ray, DEXA, computed tomography, MRI, ultrasound, and mammography services.	Lea County, NM	39.43 mi.	Present, Future

Source: C.K. Disposal, LLC, 2015; Double E Pipeline, 2022; NRC, 2015; NUREG-2237, Nor-Lea Hospital District, 2023; Permian Regional Medical Center, 2023; Seminole Hospital District, 2023
Abbreviations: NM = New Mexico | mi. = mile(s) | NRC = U.S. Nuclear Regulatory Commission | URENCO = Urenco, USA | TX = Texas | CISF = consolidated interim storage facility | DOE = U.S. Department of Energy | MW = megawatt(s) | CT = computed tomography | MRI = magnetic resonance imaging

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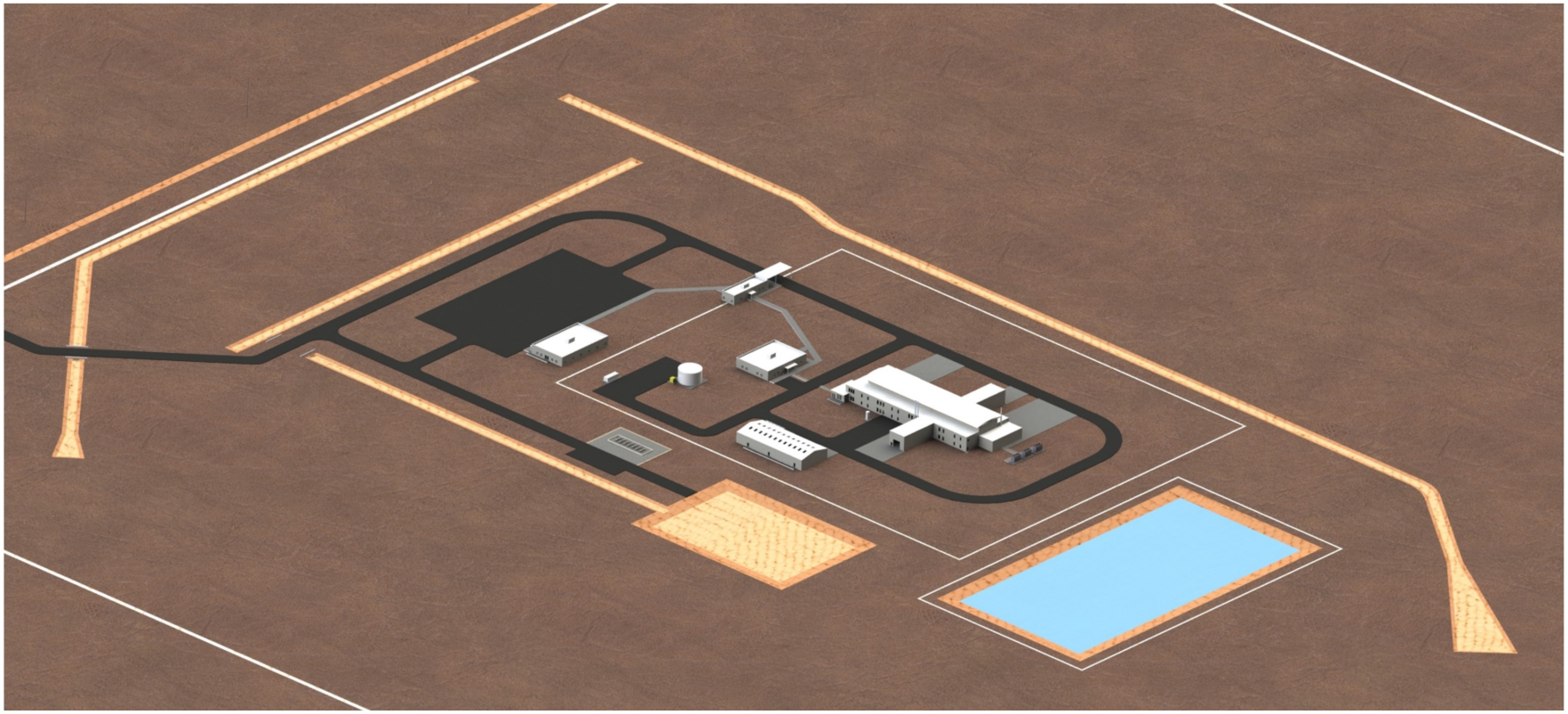
Figure 19.4.1-1
Visual Rendering of Project Site



View Looking Northeast

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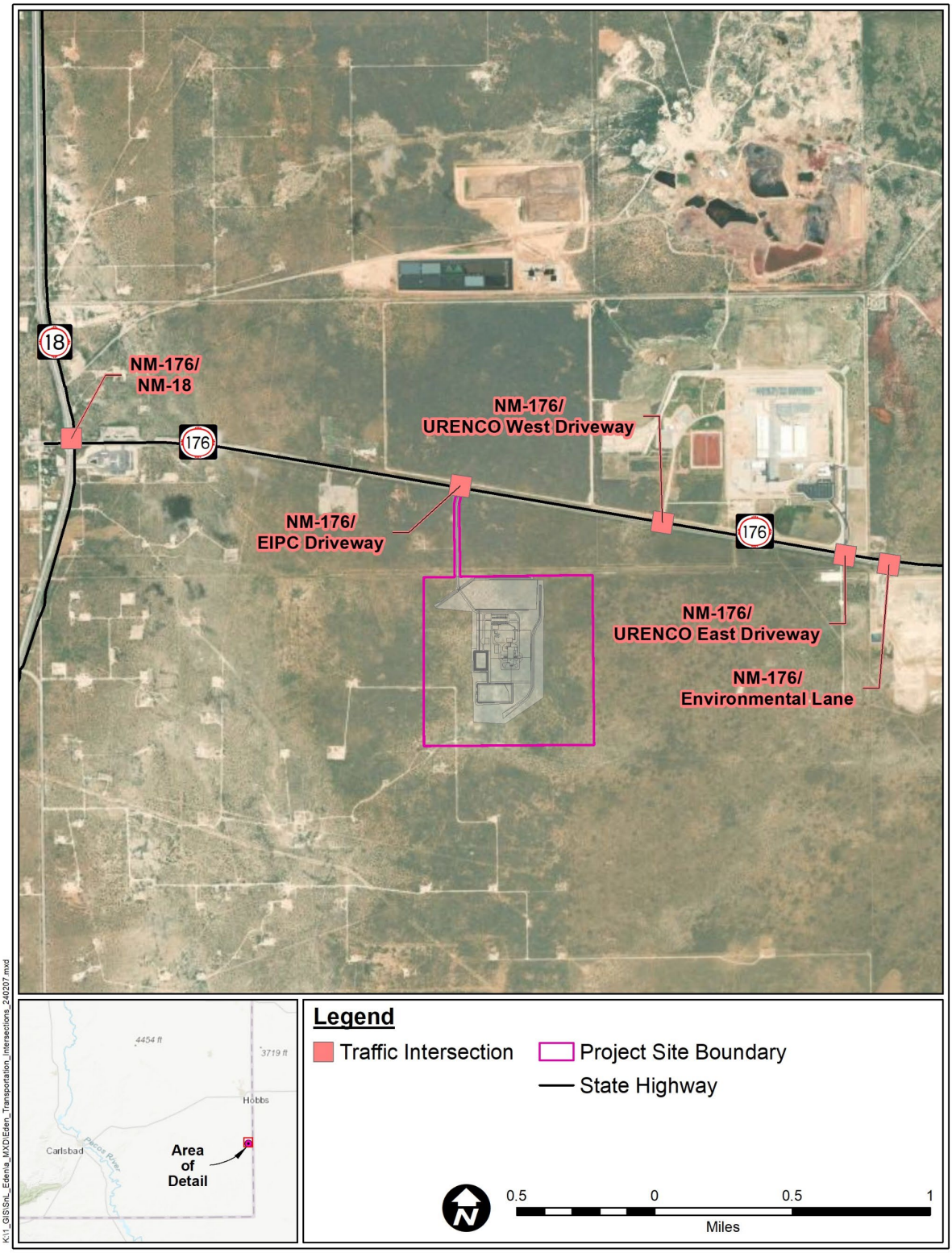
Figure 19.4.7-1
Traffic Analysis Intersections along NM-176



Eden Isotope Production Complex
Preliminary Safety Analysis Report

January 2026
Revision 0

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CHAPTER 19
ENVIRONMENTAL REPORT

SECTION 19.5 ALTERNATIVES

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
µm	micrometer(s)
ABW	air base wing
ac.	acre(s)
AFB	Air Force Base
ASCE	American Society of Civil Engineers
BISON-M	Biota Information System of New Mexico
BMP	Best Management Practice
CFR	Code of Federal Regulations
Ci	curie(s)
cm	centimeter(s)
CO	carbon monoxide
CP	construction permit
dBA	A-weighted decibel(s)
DBA	Design Basis Accident
DOE	U.S. Department of Energy
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex
EIS	Environmental Impact Statement
EJI	Environmental Justice Index
EMIF	Eden Medical Isotope Facility
EPRI	Electric Power Research Institute
ER	Environmental Report
EUL	Enhanced Use Lease

Acronym/Abbreviation	Definition
FEIS	Final Environmental Impact Statement
FEP/DUP	Fluorine Extraction Process and Depleted Uranium Deconversion Plant
ft.	foot/feet
g	gravity acceleration
GNF	General Electric Nuclear Fuels
ha	hectare(s)
HEU	highly enriched uranium
I-131	iodine-131
in.	inch(es)
IIFP	International Isotopes Fluorine Products, Inc.
INPO	Institute of Nuclear Operations
IPaC	Information for Planning and Consulting
ISG	Interim Staff Guidance
ISP	Integrated Storage Partners
KAFB	Kirtland Air Force Base
km	kilometer(s)
kV	kilovolt(s)
KO	Kimbrough gravelly loam
LEU	low-enriched uranium
LLEA	local law enforcement agency
LLW	low-level (radioactive) waste
Lu-177	lutetium-177
m	meter(s)
MDCT	mechanical-draft cooling tower

Acronym/Abbreviation	Definition
MHA	Maximum Hypothetical Accident
mi.	mile(s)
mm	millimeter(s)
Mo-98	molybdenum-98
Mo-99	molybdenum-99
Mo-100	molybdenum-100
MURR®	University of Missouri Research Reactor
NAAQS	National Ambient Air Quality Standards
NM	New Mexico
NM-176	New Mexico Highway 176
NM-483	New Mexico Highway 483
NMED	New Mexico Environment Department
NMDGF	New Mexico Department of Game & Fish
NMOCD	New Mexico Oil Conservation Division
NO_X	nitrogen oxides
NorthStar	NorthStar Medical Radioisotopes, LLC
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resource Conservation Service
NSHM	National Seismic Hazard Model
NWI	National Wetlands Inventory
NWMI	Northwest Medical Isotopes, LLC
O_3	ozone
OPAL	Open Pool Australian Lightwater
Pb	lead

Acronym/Abbreviation	Definition
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter less than 10 µm
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 µm
PPE	personal protective equipment
ROD	Record of Decision
ROI	Region of Interest
RPF	Radioisotope Production Facility
RTE	Rare, Threatened, or Endangered
SEI	Structural Engineering Institute
SGCN	Species of Greatest Conservation Need
SHINE	Shine Medical Technologies
SO_2	sulfur dioxide
TBq	terabecquerel(s)
Tc-99m	technetium-99m
TX	Texas
URENCO	Urenco USA
U.S.	United States
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCS	Waste Control Specialists
Xe-133	xenon-133
yr.	year(s)

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19.5 ALTERNATIVES

The proposed Federal action is the issuance of a Construction Permit (CP) that would allow Eden Radioisotopes, LLC (Eden) to construct an isotope production facility (or Eden Isotope Production Complex [EIPC]) to produce molybdenum-99 (Mo-99), iodine-131 (I-131), lutetium-177 (Lu-177), and xenon-133 (Xe-133) near Eunice, New Mexico (NM). This section of the Environmental Report (ER) provides a discussion of reasonable alternatives to the proposed project, including alternative sites, alternative technologies, and the no-action alternative as required by the United States (U.S.) Nuclear Regulatory Commission (NRC) Final Interim Staff Guidance (ISG) Augmenting NUREG-1537, Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors, Chapter 19.

19.5.1 NO-ACTION ALTERNATIVE

This section presents the No-Action Alternative and describes the consequences of adopting it. The proposed Federal action is the issuance of a CP that would allow Eden to construct an isotope production facility to produce Mo-99, I-131, Lu-177, and Xe-133. Under the No-Action Alternative, the NRC would not issue the CP and the construction of the EIPC would not occur. In accordance with the ISG Augmenting NUREG-1537, the environmental consequences of the No-Action Alternative are assumed to be the status quo.

If the EIPC were not constructed, any potential environmental consequences discussed in this ER are avoided. The consequences that are circumvented include adverse impacts, however minimal, such as changes in land use, water use, air emissions, impacts to threatened and endangered species and their critical habitat, and impacts to significant historic and cultural resources. However, as discussed in Section 19.4, the severity of all potential impacts to environmental and cultural resources is SMALL. Because these impacts are not significant, either individually or collectively, the benefit of avoiding such impacts are not significant. In addition, as discussed in Section 19.4.7, construction of the EIPC produces socioeconomic benefits, such as increased employment opportunities and increased tax revenues to local jurisdictions. If the EIPC is not constructed, operated, and decommissioned, these beneficial socioeconomic impacts are not realized.

In addition to the beneficial socioeconomic impacts discussed in Section 19.4.7, EIPC benefits the health of people who need diagnostic tests that require technetium-99m (Tc-99m) (the decay product of Mo-99) and the other medical isotopes that are produced by Eden. As discussed in Section 19.1, the EIPC is expected to produce 4500 six-day curies (Ci) per week of Mo-99, or approximately 100 percent of the annual U.S. demand for Mo-99 and to provide a reliable supply of diagnostic medical isotopes both domestically and internationally. A reliable domestic source of medical isotopes, including Mo-99 (used to produce Tc-99m), I-131, and Xe-133, represents a significant health benefit for the U.S. population. Eden is also projected to produce at least 60,000 Ci (2220 terabecquerels [TBq]) of Lu-177, capable of therapeutically treating several hundred thousand cancer patients per year.

The EIPC also produces significant programmatic benefits that would not be realized under the No-Action Alternative. As discussed in Section 19.1.1, commercial production of Mo-99 in the United States was limited to one producer, NorthStar Medical Radioisotopes, LLC (NorthStar). NorthStar began producing non-uranium-based Mo-99 in 2018, in collaboration with the

University of Missouri Research Reactor (MURR®) in Columbia, Missouri, using neutron capture technology to convert naturally occurring molybdenum-98 (Mo-98) to Mo-99. However, as noted in Subsection 19.1.1, NorthStar ceased production of Mo-99 and their proprietary Mo-99 / Tc-99m generator, RadioMedix, in October 2023. Thus, the United States continues to rely on Mo-99 imported from production facilities in Australia, Europe, and South Africa.

As described in Section 19.1.1, with the exception of the Open Pool Australian Lightwater (OPAL) reactor in Australia, the remaining suppliers use reactors that are over 40 years old, with a majority of the reactors being more than 50 years old. Given the age of these irradiation service supplier reactors, the potential for unplanned reactor outages and interruptions to the supply of Mo-99 and possibly Lu-177 continues to be a concern. As further described in Section 19.1.1, the reliability of the medical isotope supply chain is further jeopardized by increasing demand, both domestically and globally, by the short half-life of medical isotopes, and by potential difficulties related to the transport of medical isotopes across international borders. Because of supply chain reliability concerns, the U.S. government has formally encouraged the domestic production of medical isotopes through policy. The EIPC makes a significant contribution toward advancing this policy. The No-Action Alternative does not alleviate concerns about the medical isotope supply train and does not support the U.S. government policy encouraging the domestic production of medical isotopes.

As described in Subsection 19.1.1.5, the EIPC also helps support U.S. government non-proliferation objectives. Historically, medical isotopes were produced by irradiating highly enriched uranium (HEU) targets exported from the United States for medical isotope production. However, in 1992 the U.S. Congress passed the Energy Policy Act of 1992, which included a non-proliferation objective to phase out exports of HEU. The American Medical Isotopes Production Act of 2012 (Public Law 112-239) also contains provisions to eliminate the use of HEU for medical isotope production and encourages the development of U.S. domestic supplies of Mo-99 and associated isotopes. Based on these actions, the U.S. government is encouraging medical isotope production without the use of HEU. The EIPC uses low-enriched uranium (LEU) to produce medical isotopes, thereby reducing the need for HEU and helping to further the non-proliferation objective. Under the No-Action Alternative, this benefit is not realized.

19.5.2 REASONABLE ALTERNATIVES

This subsection provides a discussion of reasonable alternatives to the proposed project as required by the ISG Augmenting NUREG-1537. The subsection includes a description of the process used by Eden to formulate and determine reasonable alternatives to the proposed action, a description of alternatives considered, and an indication as to which alternatives were eliminated from further study. The following types of alternatives are discussed:

- Alternative sites.
- Alternative technologies.

Both beneficial and adverse impacts to environmental resources are described for the alternative sites and technologies. The analysis of reasonable alternatives includes direct, indirect, and cumulative impacts analyzed in proportion to their significance.

19.5.2.1 Reasonable Alternative Sites

This subsection provides a description of the process used by Eden to formulate and determine reasonable alternative sites for the proposed EIPC. The selection of a site for the proposed

project considered a variety of engineering, environmental, social, and socioeconomic criteria, including site geography, land availability, land use, environmental features, existing infrastructure, public acceptance, and logistics. The site selection process applied by Eden was designed to maximize the potential for a successful project and to optimize benefits to the host-community while minimizing negative impacts to the public and the environment. Site evaluation scoring and results are provided in Tables 19.5.2-1 and 19.5.2-2.

19.5.2.1.1 Identification of Reasonable Alternative Sites

As an initial step in the EIPC site location process, Eden identified a limited number of critical infrastructure and technical resources needed for a successful medical radioisotope production complex. The key infrastructure and technical resources determined to be critical for a successful project are:

Skilled Scientific and Technical Workforce

The proposed site is strategically located near to other existing nuclear-related facilities, and a nuclear-educated workforce is already resident within Lea County, NM, and nearby Andrews County, Texas (TX). This workforce is anticipated to expand over time as the proposed new projects become operational. These facilities are described in Table 19.4.13-1 and are listed below:

- The Urenco USA (URENCO) fuel enrichment facility is approximately 1.3 miles (mi.) (2.1 kilometers [km]) northeast of the proposed project site directly across New Mexico Highway 176 (NM-176) from the proposed EIPC. This facility produces uranium fuel for commercial nuclear power plants.
- Waste Control Specialists (WCS), located in Andrews County, TX, is approximately 2.6 mi. (4.2 km) away from the site boundary. WCS operates two facilities authorized to dispose of mixed Class A, B, and C low-level radioactive waste (LLW). WCS would dispose of LLW from the EIPC.
- Waste Facility Expansion by Integrated Storage Partners (ISP) is located within the WCS site envelope. ISP submitted a license for construction and operation of a consolidated interim storage facility at the existing WCS site for 5500 short tons of uranium. NRC has granted a license and construction has not yet begun.
- Waste Isolation Pilot Plant is a permanent disposal facility for transuranic waste located approximately 41 mi. (66 km) away from the project site.
- Holtec-Hi-Store Consolidated Interim Storage facility is a centralized facility for storage of used nuclear fuel and high-level radioactive waste until such a time that a permanent solution is available. This facility is located approximately 38 mi. (61 km) from the project site.
- International Isotopes, Inc is located approximately 24 mi. (39 km) northwest. It is a proposed depleted uranium deconversion facility that would use the depleted uranium hexafluoride from URENCO to produce fluoride.

Both Lea County, NM, and Andrews County, TX, continue to be supportive of the nuclear facilities described above that are in operation, as well as the planned future projects.

A recent example of training and involvement described on the URENCO website states the following (URENCO, 2024):

In early March 2024, URENCO USA had the opportunity to host a remote training location for INPO's [Institute of Nuclear Operations'] First Line Leadership Training in Hobbs, NM. This four-day leadership training was provided to twenty-four UUSA Employees and seven participants from General Electric Nuclear Fuels (GNF). GNF, a partner in the Nuclear fuel cycle, processes enriched uranium into nuclear fuel pellets for power plants.

The INPO First Line Leadership training, geared towards current supervisors and emerging leaders, offers a variety of learning activities and breakout sessions. Key themes from the seminar include inspirational leadership, coaching, observations and standards, communication, and integrity.

Shared Nuclear Infrastructure

- Given the close proximity to the URENCO facility, early informal discussions held in 2023 with URENCO included the possibility of sharing selective administrative and technical support resources after the proposed facility becomes fully operational. These discussions touched upon the following categories of support services:
  - Administration/Support Services.
  - Procurement.
  - Engineering & Maintenance.
  - Quality Assurance.
  - Regulatory/Environmental/Industrial Safety.
  - Radiation Protection/Health Physics.
  - Emergency Planning.
  - Physical Security/Guard Force.
  - Material Control and Accounting Plan.
  - Nuclear Safety Program.
- In addition, given the close proximity to the WCS low-level disposal facility, radioactive waste from operations is planned to be transported by truck to the WCS disposal facility. WCS has served as a long-term storage facility for nuclear power plants, industrial facilities, hospitals, research centers, and the U.S. Department of Energy (DOE). As noted in Subsection 19.2.8.5.3, the highway distance from the proposed facility to the disposal facility is approximately 2 mi. (3.2 km) with approximately 10 waste delivery trips per year made.
- Nonradioactive waste from operations and decommissioning is transported by truck to the Lea County Landfill, about 1.5 mi. (2.5 km) away by road.

Land Availability

- As noted in Subsection 19.3.1.1, the proposed site consists of 245.6 acres (ac.) (99.4 hectares [ha]) that have historically been used for cattle grazing. The region surrounding the proposed site spans Lea County, NM, and Andrews County, TX. The dominant land use in the region is scrub/shrub, accounting for 92 percent of the area. Approximately 6.5 percent of the region is defined as developed. Additionally, there are high-intensity and multiple industrial and developed facilities located within the region. The only major population center within the region is Eunice, NM, located approximately 1.4 mi. (2.2 km) west of the project site and home to approximately 3000 residents.

Favorable Geography and Geology

As noted in Section 19.3, the proposed project site is in a seismically quiet region, with nearby seismic events being of small magnitude and generally caused by oilfield injection activities. No mapped Holocene Epoch faults exist in the area, and the potential for liquefaction and other earthquake-related hazards at the project site is low.

Available Transportation

The medical isotopes to be produced at the proposed facility are transported by truck to airports in New Mexico and in Texas, where they are transported by air to various facilities for generator loading and distribution to medical facilities. Three to five product delivery trips via air travel are made weekly. As noted in Subsection 19.2.8.5.2, there are five airports located within 150 mi. (241 km) of the proposed facility. These are:

- Lea County Regional Airport (Hobbs, NM): approximately 26 mi. (42 km).
- Midland International Air and Space Port (Midland, TX): approximately 72 mi. (116 km).
- Cavern City Air Terminal (Carlsbad, NM): approximately 78 mi. (126 km).
- Roswell Air Center (Roswell, NM): approximately 128 mi. (206 km).
- Lubbock Preston Smith International Airport (Lubbock, TX): approximately 134 mi. (216 km).

In summary, although many locations within the boundaries of the United States could be considered potential locations for a medical radioisotope production facility, conclusions reached as a result of the review of the critical infrastructure and technical resource needs listed above focused Eden's search for a preferred location in central and eastern New Mexico. This geographical area was chosen based on Eden's familiarity with the area, local government and community acceptance of other nuclear facilities, availability of a skilled scientific and technical workforce, available shared nuclear infrastructure, and proximity to a LLW disposal site.

19.5.2.1.1.1 Prior Alternative Site Evaluation – Albuquerque, NM, General Area

The Albuquerque, NM, general area is considered a plausible alternative to the preferred location for the proposed isotope production facility located near Eunice, NM. Possible locations within the Albuquerque, general area include Native American reservations, Kirtland Air Force Base (KAFB), and private land in or outside of industrial parks.

In April 1996, the DOE issued, with the support of Pacific Northwest National Laboratory, a Final Environmental Impact Statement (FEIS) as a part of its planning and sponsorship of a Medical Isotope Production Project (DOE, 1996a; DOE, 1996b). In September 1996, after receipt and disposition of public comments, the DOE issued a Record of Decision (ROD) for the proposed DOE Medical Isotope Production Project (DOE, 1996c). The ROD identified the Sandia National Laboratories site in Albuquerque, NM, located within the KAFB complex as one of the preferred locations for this facility. Based on the information provided in the FEIS and ROD, Eden elected to further evaluate KAFB because it appeared to be representative of the Albuquerque, general area.

Subsequently, in January 2019, the United States Air Force (USAF) released a Final Report titled "Final Description of Proposed Action and Alternatives for the Enhanced Use Lease

Redevelopment Environmental Assessment at Kirtland Air Force Base, New Mexico" (USAF, 2019). In that report, the USAF states:

> The USAF is proposing to redevelop the underutilized portion of land on Kirtland AFB [Air Force Base] through an Enhanced Use Lease (EUL). The Proposed Action would develop a 77-ac. underutilized site and evaluate a 23-ac. developable site for future use at Kirtland AFB into a mixed-use development that could include office, retail/commercial, multifamily housing, hotel, gasoline station, and restaurant space uses. Roadways for access and vehicular movement through the development, parking, and landscape areas would be constructed as well as utility infrastructure to support activities at the study area.

Eden recognizes that land available for lease for the EIPC would primarily be DOE-owned land in restricted areas within the confines of the KAFB. However, the decision described above regarding USAF-owned portions of the air force base suggests that redevelopment efforts may expand significantly in the future, raising potential environmental and logistical concerns for the planned life of the EIPC.

Further, regarding the current mission of the KAFB, the January 2019, USAF Report states:

> Kirtland AFB is the sixth largest installation in the USAF. It is operated by 377 Air Base Wing (ABW), a unit of Air Force Global Strike Command's 20th Air Force and the host unit at Kirtland AFB. Missions at Kirtland AFB fall into four major categories: research, development, and testing; readiness and training; munitions maintenance; and support to installation operations for more than 100 mission partners. The primary mission of 377 ABW is to execute nuclear, readiness, and support operations for American airpower. Kirtland AFB is a center for research, development, and testing of non-conventional weapons, space and missile technology, laser warfare and much more. Organizations involved in these activities include the Air Force Nuclear Weapons Center, Air Force Operational Test and Evaluation Center, Space and Missile Systems Center, Air Force Inspection Agency, Air Force Safety Center, Air Force Research Laboratory, DOE, and Sandia National Laboratories. In addition, 377 ABW ensures readiness and training of airmen for worldwide duty and operates the airfield for present and future USAF operations, prepares personnel to deploy worldwide on a moment's notice, and keeps the installation secure. Mission partners involved in these activities include the 58th Special Operations Wing, 150th Special Operations Wing (New Mexico Air National Guard), and the USAF Pararescue School.

Siting of the EIPC on KAFB would affect Eden's ability to fully control all aspects of construction and operations. The facility's construction schedule could be negatively affected by the amount of time required to engage in negotiations with the USAF and the DOE and come to an agreement to obtain permission for land use. Once constructed, facility operations would be subject to the priorities, agreements, and control of the authorities on base. It is also reasonable to assume that traffic on base is stopped for periods of time to accommodate air force base missions, training, and potential security alerts and threats. Perturbations in transportation would negatively affect Eden's ability to reliably transport product to scheduled flights for delivery to customers. Such delays are unfavorable because they result in a reduction of delivered product due to Mo-99's relatively short half-life of 66 hours.

KAFB is bounded on the south by the Isleta Pueblo reservation, on the east by national forest land, and on the north and west by the City of Albuquerque. Although the DOE FEIS states that there was general acceptance and support by the community, the proximity to a large urban area and to a Native American reservation makes the acquisition of acceptance and support from the public a more challenging effort than is the case for less urbanized areas.

Therefore, the KAFB site location was eliminated from detailed discussion based on the conclusion that locating a private isotope production facility within the bounds of an existing federal facility would not be practicable because of potential site access restrictions and increased contracting, licensing, and permitting requirements.

19.5.2.1.1.2 Sites Identified for Detailed Evaluation

After focusing the Region of Interest (ROI) on central and eastern NM, Eden proceeded to identify potential locations for the proposed EIPC. Eden identified potential locations within the central and eastern New Mexico area based on an assessment of specific nondiscretionary site development, engineering, and environmental criteria determined to be essential for the successful development of a medical radioisotope production facility. Site locations that did not meet one or more nondiscretionary criteria were eliminated from further consideration. Nondiscretionary criteria upon which Eden identified viable potential site locations included:

- Candidate sites must have at least 200 ac. (81 ha) available for development to accommodate the medical isotope manufacturing facility and the associated support facilities, including construction laydown and temporary and permanent parking.
- Sites must meet the following topographic, geologic, and site development constraints:
    - Total ground slope across that portion of the site designated for development must be no more than 5 percent.
    - Sites with significant shallow rock (i.e., rock surface located 1 foot [ft.] [0.3 meters {m}] or less below the foundation depth) were eliminated from further consideration.
    - Sites with shallow groundwater (i.e., groundwater table 2 ft. [0.6 m] or less below the surface) were eliminated from further consideration.
    - The entire site must be above the 100-year flood level, or it must be technically feasible to protect the entire site from the 100-year flood.
    - Sites must be located 5 mi. (8 km) or more from an active fault.
- Sites must meet the following access and infrastructure criteria:
    - Access to adequate electric power, adequate natural gas, municipal water and sewer, and communication infrastructure must be available within 10 mi. (16 km) of the site.
    - The site must be located within 20 mi. (32 km) of a primary state or interstate highway.
    - The site must be located within 50 mi. (80 km) of a suitable commercial airport for product distribution.
    - The site must be located within 30 mi. (48 km) of a Local Law Enforcement Agency (LLEA).

In addition, the site must not be located under active airport approach patterns, holding patterns, or active military training or operation areas, as sites located under such air spaces expose the facility to increased security concerns and require significant design changes.

Sites must meet the following minimum environmental and social criteria:

- Site locations must not be listed on the United States Environmental Protection Agency's (USEPA) National Priorities List (NPL).
- Site locations must not be occupied by residential or recreational developments.
- There must be no designated critical habitat within the site boundaries.
- There must be no known significant historic or cultural resources and the site must not include properties listed by the U.S. National Park Service or on the National Register of Historic Places.

Applying the nondiscretionary or exclusionary criteria listed above to potential locations within central and eastern New Mexico, Eden identified the following three sites for detailed review and evaluation:

- Proposed Eunice Site, Eunice, Lea County, NM.
- EnergyPlex Park (EnergyPlex) Site, Hobbs, Lea County, NM.
- International Isotopes Fluorine Products, Inc. (IIFP) Site, Hobbs, Lea County, NM.

All three potential site locations can be characterized as sites within the ROI that meet all nondiscretionary criteria and are available for project development. The general locations of the Proposed Eunice Site and the two alternative sites are shown in Figure 19.5.2-1, and site maps of each of the sites are shown in Figure 19.5.2-2, 19.5.2-3, and 19.5.2-4.

19.5.2.1.1.3 Evaluation of Preferred and Alternative Sites

The Alternative Site Study was prepared to select a preferred site for the proposed EIPC. Sites were evaluated based on engineering, environmental, socioeconomic, and community acceptance criteria. The primary objective of the Alternative Site Study was to determine, based on objective criteria, if any of the reasonable alternative sites were obviously superior to the preferred site, or if some or all the sites were generally equivalent and suitable for development of the proposed facility.

19.5.2.1.1.4 Alternative Site Evaluation Methodology

The Alternative Site Study used a quantitative numerical scoring system designed to identify, rank, and score potential advantages or disadvantages associated with the alternative sites. Alternative sites were assessed based on a detailed evaluation of selected site criteria. The primary objective of the evaluation was to produce numerical scores that would allow the alternative sites to be ranked according to their overall suitability for the development of the EIPC, and document whether any site is obviously superior from an environmental perspective as required by 10 Code of Federal Regulations (CFR) Part 51. The higher the score, the more suitable the site is for the project.

Quantitative criteria were developed to generate numerical scores that reflect how well each site satisfied criteria considered necessary to successfully license and develop the medical isotope production facility. Criteria were developed for 35 specific site characteristics related to engineering, environment, socioeconomics, and community acceptance. Site evaluation criteria include both an objective means of assigning a numerical score for each criterion and importance weighting factors, which were used to adjust the numerical scores based on the relative importance of the specific criterion. Site criteria weighting factors developed for the

evaluation were consistent with the Electric Power Research Institute (EPRI) Siting Guide (EPRI, 2002) and with the methods used for other nuclear facility siting studies.

The main categories of criteria evaluated for the alternative and proposed sites include the following:

- Local infrastructure and utilities.
- Site development, constructability, seismic, and geotechnical.
- Environmental and natural resources.
- Land use, socioeconomics, and community acceptance.

Local Infrastructure and Utilities

The criteria for local infrastructure and utilities include the following:

- Site Utilities: Site utilities, including water and sewer, electricity, gas, and communications are considered important for any project, and their availability within a reasonable distance from a site is important for site development, cost, and permitting perspectives.
- Highway Access: Sites that are located 1 mi. (1.6 km) or less from a primary state or interstate highway and that do not require travel through a residential area are given the highest rating.
- Airport Access: Sites that are located within 10 mi. (16.1 km) of an adequate airport are given the highest rating.
- Access to Emergency Health Care: This criterion is considered important due to the potential need for emergency care services. The closer the health care facility is to the site, the higher the rating.
- Distance to LLEA: The purpose of this criterion is to minimize the distance to the LLEA for quicker LLEA response times. Shorter distances are rated higher than longer distances.

Site Development, Constructability, Seismic, and Geotechnical Considerations

These criteria relate to the ability to construct a site at the proposed and alternative site locations. These criteria include the following:

- Size and Topography: The basic criteria applied to the site are the availability of the required minimum area and ground slope. If the general ground slope is 1 percent, based on a review of available topographic imagery, the site is ranked higher.
- Soil Suitability for Earthwork, Building Foundations, and Pipe Installation: Site soils and geology are reviewed to evaluate sites for deep deposits of loose, soft, or highly expansive material, which affects site development and costs. Sites are rated higher if the soils are granular and the rock surface is 5 ft. (1.5 m) or more below foundation depth.
- Shallow Rock: Sites with rock strata 5 ft. (1.5 m) or more below the foundation depths are ranked higher.

- Groundwater Conditions: Sites with groundwater table 5 ft. (1.5 m) or more below the foundation depth are ranked higher over sites with a shallower groundwater.
- Flood Protection: Sites located above the 100-year and 500-year floodplains with no upstream dams or levees are ranked higher. Also, the nearest river or stream should be more than 2.5 mi. (4 km) from the site and/or the elevation difference between the site and river water surface should be 100 ft. (30.5 m) or more.
- Constructability: Sites that have not previously been developed do not require excavation of caliche or cemented material and that do not require demolition or relocation of existing structures, overhead transmission lines, or underground pipelines are ranked higher.
- Aircraft Hazards: For reasons associated with facility design and construction costs, as well as site safety and security reasons, sites should not be located directly under or in proximity to a federal airway, airport holding pattern or approach pattern, or military training and operation areas.
- Proximity to Active and Inactive Faults: Sites that are located more than 200 mi. (322 km) from any active fault and with no inactive faults within 50 mi. (80.5 km) of the site are ranked higher.
- Seismic Hazard: Sites with a design basis peak acceleration of 0.2 times the acceleration of gravity (g) or less are ranked higher.
- Settlement and Liquefaction Potential: Sites with rock strata 1 – 20 ft. (0.3 – 6.1 m) below the foundation depths are ranked higher. Sites with uncompacted fills below groundwater are not preferred and scored lower.
- Karst, Sinkholes, and Subsidence: Sites located in karst-free zones are ranked higher.

Environmental and Natural Resources

These criteria relate to minimizing impact to environmental and natural resources. The criteria include the following:

- Rare, Threatened, or Endangered (RTE) Species: Sites with no known occurrences of federal- or state-protected RTE species and with a low potential for RTE occurrences are ranked higher.
- Designated Critical Habitat: Sites with no designated critical habitat for federal- or state-protected species located within the vicinity of the site (i.e., less than or equal to 1 mi. [1.6 km] from a site boundary) are ranked higher.
- On-Site Natural Habitats: Sites with little or no natural habitat, including forests, woodlands, prairies, or other natural areas are ranked higher.
- Surface Water Resources: Sites that are not crossed by rivers or streams or occupied by lakes, wetlands, or other USEPA Waters of the United States are ranked higher.
- Regional Air Resources: Sites located within airsheds that meet all National Ambient Air Quality Standards (NAAQS) are ranked higher.
- Proximity to Natural Areas: Sites located away from natural areas, including federal, state, and local parks, botanic gardens, and undeveloped lake and greenspace, are ranked higher.

- Groundwater and Drinking Water Resources: Sites that are not located over an aquifer used for potable water are ranked higher.
- Prime Farmland: Sites that are not characterized as prime farmland are ranked higher.
- Proximity to Hazardous Land Uses: Sites with no identifiable hazardous land uses located within 5 mi. (8 km) of the site boundary are ranked higher.
- Proximity to Contaminated Properties: Sites that are located away from properties with known contamination or ongoing environmental remediation activities are ranked higher.

Land Use, Socioeconomics, and Community Acceptance

The following criteria was used to evaluate land use, socioeconomics, and community acceptance:

- Existing Land Use On-Site: Compatible land uses, including existing NRC-licensed facilities and unused, uncontaminated “brownfield” land are ranked higher.
- Existing Land Use within 1 mi. (1.6 km) of the Site: Existing land use in the site vicinity is evaluated separately from existing on-site land use. Existing land use that is highly compatible (e.g., industrial, mineral extraction, or power generation) is ranked highest.
- Zoning and Land Use Planning: Sites that are located in an area that is zoned for highly compatible activities (e.g., heavy industry) and sites that are located in an area that is not subject to specific zoning restrictions ranked higher.
- Parks and Recreation: Sites with no parks or recreation areas located within 1 mi. (1.6 km) of any site border are ranked higher.
- Historic and Cultural Resources: Sites that have been extensively surveyed with no significant cultural resources found and/or sites that have been previously disturbed are preferred.
- Aesthetic and Noise Impacts: Sites located away from sensitive receptors, such as residences, religious facilities (e.g., churches), schools, assisted-living facilities), and dining/drinking establishments are ranked higher. Sensitive receptors located with 0.25 mi. (0.4 km) of the site boundary are identified based on a review of published maps and aerial imagery.
- Environmental Justice: Sites are scored based on a review of the USEPA’s Environmental Justice Index (EJI) within a 5-mi. (8.0-km) radius of the site, including both environmental and demographic indexes.
- Existing Nuclear Infrastructure – Public Acceptance: Public acceptance of the proposed project or potential opposition to the proposed project is evaluated based on a review of other existing nuclear infrastructure located in the vicinity of the site. Sites located in an area with existing nuclear infrastructure and no history of significant public opposition are ranked higher.
- Public Support and Financial Incentives: Sites are scored based on state and local taxes, the availability of tax incentives (e.g., programs to reduce taxes for companies creating new jobs and property tax incentives), employment hiring credits, employee training programs, and similar.

19.5.2.1.1.5 Identification of the Preferred and Alternative Sites

A summary of the site selection study evaluation and scoring is provided in Tables 19.5.2-1 and 19.5.2-2. Based on the evaluation of the reasonable alternative sites, all three sites are considered suitable for the development of the project from engineering, environmental, socioeconomic, and community acceptance standpoints, and none of the reasonable alternative sites is obviously superior to the Proposed Eunice Site. Major direct and indirect impacts resulting from the EIPC at the Proposed Eunice Site located near Eunice, NM, as assessed in Section 19.4, are similar for all sites, and none of the reasonable alternative sites evaluated reduces or avoids adverse effects associated with the proposed project, all of which are characterized as SMALL. Based on the results of the Alternative Site Study, the Eunice Site was selected as the proposed location for the EIPC, and the EnergyPlex Park and IIFP sites were both considered to be reasonable alternatives.

19.5.2.1.2 Evaluation of Reasonable Alternative Sites

As described above, the EnergyPlex Park Site and IIFP Site were both determined to be viable sites and reasonable alternatives to the Proposed Eunice Site. This subsection provides a detailed evaluation of the two alternative sites, including an evaluation of the major direct, indirect, and cumulative environmental impacts associated with locating the EIPC at those sites. Information for the evaluation was obtained based on findings published in the Alternative Site Study, including published data from federal and state regulatory agencies, examination of published maps and aerial imagery, analysis of digitized geographic information system mapping data, and assessment of previously published environmental assessments. Detailed analysis and source reference documents are provided in the Alternative Site Study.

In order to evaluate potential environmental impacts associated with construction, operation, and decommissioning of the EIPC at the alternative site locations, facility design parameters described in Section 19.2, and construction, operation, and decommissioning impacts described in Section 19.4 were assessed for each site. Potential impacts from construction, operation, and decommissioning of the EIPC were evaluated for each resource category specified in the ISG Augmenting NUREG-1537 and assigned a significance level according to the criteria established therein, as follows:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purpose of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered SMALL.
>
> MODERATE – Environmental effects are sufficient to noticeably alter important attributes of the resource but not to destabilize them.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In addition to the direct and indirect impacts associated with the construction, operation, and decommissioning of the EIPC at the alternative site locations, related cumulative impacts from other past, present, and reasonably foreseeable future federal and non-federal projects in the area around each site were considered.

The following subsections summarize the evaluation of each alternative site.

19.5.2.1.2.1 General Site Descriptions

EnergyPlex Park Site, Hobbs

The EnergyPlex Park site is located approximately 12 mi. (19.3 km) northwest of the City of Hobbs, NM. The parcel has more than 800 ac. (324 ha) of open area available for development. The site is located adjacent to, and east of, New Mexico Highway 483 (NM-483) (Arkansas Junction) and approximately 5.5 mi. (8.9 km) north of the intersection of NM-483 and U.S. Highway 62/180 (Carlsbad Highway). The site is accessible from NM-483 via the construction of a new access road. Several existing Lea County, and City of Hobbs, utilities are located in proximity to the site. An existing water well and 8-inch (in.) (20.3-centimeter [cm]) waterline, which could be extended to the proposed EnergyPlex Park Site, are both located within the EnergyPlex Park complex. An existing 115-kilovolt (kV) transmission line, which could be extended to the proposed site, passes through the EnergyPlex Park complex. An existing 8-in (20.3 cm) natural gas line, which runs parallel to U.S. Highway 62/180, is located approximately 5 mi. (8 km) from the site and could be extended to the proposed EnergyPlex Park Site. Cell phone communication towers and fiber optic infrastructure have been developed within the EnergyPlex Park complex.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

The IIFP Site is located approximately 11.5 mi. (18.5 km) west of the City of Hobbs, NM. The parcel has approximately 200 ac. (81 ha) of open area available for development. The site is located approximately 4 mi. (6.4 km) south of the southwest corner of the EnergyPlex Park complex. The IIFP Site is located adjacent to, and east of NM-483 (Arkansas Junction) and approximately 1.5 mi. (2.4 km) north of the intersection of NM-483 and U.S. Highway 62/180 (Carlsbad Highway). The site, which is accessible from NM-483, would be located adjacent to a proposed Fluorine Extraction Process and Depleted Uranium Deconversion Plant (FEP/DUP) being developed by IIFP. Several existing Lea County, and City of Hobbs, utilities are located in proximity to the site. An existing water well and 8-in (20.3 cm) waterline, which could be extended to the proposed IIFP site, are located within the EnergyPlex Park complex. An existing 115-kV transmission line, which could be extended to the proposed site, passes through the EnergyPlex Park complex. An existing 8-in (20.3 cm) natural gas line, which runs parallel to U.S. Highway 62, is located approximately 1.5 mi. (2.4 km) from the site and could be extended to the proposed IIFP Site. Cell phone communication towers and fiber optic infrastructure developed within the EnergyPlex Park complex would provide communication service to the IIFP site.

19.5.2.1.2.2 Land Use and Visual Resources

19.5.2.1.2.2.1 Land Use

EnergyPlex Park Site, Hobbs

Existing land use within the EnergyPlex Park Site boundary is agricultural. Vegetation in the area is generally dominated by Plains Sand Scrub vegetation communities characterized by the presence of forbs, shrubs, and grasses that are adapted to the deep sand environment that occurs in parts of southeastern New Mexico. No on-site oil or gas wells were identified within the EnergyPlex Park Site boundaries based on published NM Oil Conservation Division

(NMOCD) Oil and Gas Map data, and no gas transmission or hazardous liquid pipelines were identified within the site boundary.

Based on a review of National Resource Conservation Service (NRCS) soils data, 20.4 percent of the EnergyPlex Park Site is designated farmland of statewide importance; however, given the size of the proposed project and the area of land that is disturbed by construction of the EIPC, there is no basis to conclude that construction and operation of the EIPC interfere with or have an adverse impact on land use resources within Lea County. Construction would change portions of the site from predominantly agricultural use to industrial use, which would noticeably alter the existing land use resources of the site; however, this alteration is consistent with the intended land use in the area. Therefore, the land use impact due to project construction would be SMALL. During decommissioning, the land use for the EIPC is bounded by the land use during construction and is considered SMALL.

During operation of the EIPC, land use impacts would be further reduced, and some areas that were temporarily disturbed for construction laydown and parking may be returned to rangelands. Therefore, the land use impact due to operation of the EIPC is SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Based on a review of aerial imagery, existing land use within the IIFP Site consists of vacant undeveloped land or land used for grazing. Vegetation in the area is generally dominated by Plains Sand Scrub vegetation communities characterized by the presence of forbs, shrubs, and grasses that are adapted to the deep sand environment that occurs in parts of southeastern New Mexico. No on-site oil or gas wells were identified within the IIFP Site boundaries based on published NMOCD Oil and Gas Map data. Based on a review of published National Pipeline Mapping System data, several gas transmission and hazardous liquid pipelines are located within the site.

Based on a review of NRCS soils data, 20.1 percent of the IIFP Site is designated farmland of statewide importance; however, given the size of the proposed project and the area of land that is disturbed by construction of the EIPC, there is no basis to conclude that construction and operation of the EIPC interfere with or have an adverse impact on land use resources within Lea County. Construction would change portions of the site from predominantly undeveloped grazing use to industrial use, which would noticeably alter the existing land use resources of the site; however, this alteration is consistent with the intended land use in the area. Therefore, the land use impact due to project construction is SMALL. During decommissioning, the land use for the EIPC is bounded by the land use during construction and is considered SMALL.

During operation of the EIPC, land use impacts would be further reduced, and some areas that were temporarily disturbed for construction laydown and parking may be returned to rangelands. Therefore, the land use impact due to operation of the EIPC is SMALL.

19.5.2.1.2.2.2 Visual Resources

EnergyPlex Park Site, Hobbs

Visual resources in the vicinity of the EnergyPlex Park Site could be affected by the construction of new structures and construction equipment. During construction, temporary localized visual impacts would likely occur as a result of heavy equipment being present on-site and construction materials being staged on-site within laydown areas, as well as a regular presence

of large transport vehicles and construction trailers. Construction-related fugitive dust emissions could also result in short-term transient visual impacts. Similar visual impacts as those experienced during construction would also be expected during site decommissioning; however, the magnitude of such impacts would be expected to be bounded by those seen during construction.

Existing land use within the EnergyPlex Park Site boundary currently consists of agricultural and grazing, with no existing architectural features, established structures, or natural or built barriers, screens, or buffers. The visual setting of the EnergyPlex Park Site is generally flat and uniform in landform with low vegetation diversity; consequently, construction of the EIPC would alter site conditions and partially obstruct views of the existing landscape. Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the proposed EnergyPlex Park Site are agricultural, rangelands, used for mineral extraction, or industrial land use, and there are no residents located within 1 mi. (1.6 km) of the site. Based on these site characteristics, the impact to the EnergyPlex Park viewshed due to construction and decommissioning is SMALL.

The impact of the EIPC on visual resources during operation at the Proposed Eunice Site is addressed in Subsection 19.4.1.2. These impacts would also apply to the EnergyPlex Park Site, and the severity of visual impacts on the human population is largely determined by the visibility of the project facilities from sensitive viewing areas. The EIPC structures include an administration office complex, production office complex, production warehouse, and the Eden Medical Isotope Facility (EMIF). The bounding height of the EIPC for visual impact assessment is the EMIF, which is approximately 42 ft. (12.8 m) high. Figure 19.4.1-1 presents a conceptual rendering of the facility and the arrangements on-site. Visual cooling tower plumes during operation are those elevated plumes that occur during daylight and have sufficient optical density to appear opaque to an observer. Cooling tower plumes are evaluated based on historical meteorological data from 2018 – 2022. Based on the evaluation, the largest visual impacts occur within 656 ft. (200 m) of the cooling towers. The number of hours per year with visual plumes ranges from approximately 27 hours to 51 hours.

Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the proposed EnergyPlex Park Site are agricultural, rangelands, used for mineral extraction, or industrial land use, and there are no residents located within 1 mi. (1.6 km) of the site. Based on these site characteristics, the bounding dimensions of the EIPC and the bounding visual impacts associated with cooling tower plume and applying the criteria for judging the significance of environmental impacts discussed in the ISG Augmenting NUREG-1537, impacts to the EnergyPlex Park Site viewshed during operation are SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Visual resources in the vicinity of the IIFP Site could be affected by the construction of new structures and construction equipment. During facility construction temporary localized visual impacts would likely occur as a result of heavy equipment being present on-site and construction materials being staged on-site within laydown areas, as well as a regular presence of large transport vehicles and construction trailers. Construction-related fugitive dust emissions could also result in short-term transient visual impacts. Similar visual impacts as those experienced during construction would also be expected during site decommissioning; however, the magnitude of such impacts would be expected to be bounded by those seen during construction.

Existing land use within the IIFP Site boundary currently consists of undeveloped vacant land and land used for limited grazing, with no existing architectural features, established structures, or natural or built barriers, screens, or buffers. The visual setting of the IIFP Site is generally flat and uniform in landform with low vegetation diversity; consequently, construction of the EIPC alters site conditions and partially obstructs views of the existing landscape. Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the proposed IIFP Site are undeveloped, used for mineral extraction, or are industrial land use, and there are no residents located within 1 mi. (1.6 km) of the site. Based on these site characteristics, the impact to the IIFP Site viewshed due to construction and decommissioning is SMALL.

The visual impacts associated with cooling tower plume during operation at the IIFP Site would be the same as the impacts of cooling tower plume associated with the EnergyPlex Park Site noted above.

Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the proposed IIFP Site are undeveloped, used for mineral extraction, or are industrial land use, and there are no residents located within 1 mi. (1.6 km) of the site. Based on these site characteristics, the bounded dimensions of the EIPC and the bounding visual impacts associated with cooling tower plume, and the criteria for judging the significance of environmental impacts discussed in the ISG Augmenting NUREG-1537, impact to the IIFP Site viewshed during operation is SMALL.

19.5.2.1.2.3 Air Quality and Noise

19.5.2.1.2.3.1 Air Quality

EnergyPlex Park Site, Hobbs

The EnergyPlex Park Site is located in Lea County, NM. The ambient air quality in Lea County currently is in attainment with the NAAQS for all criteria pollutants (ozone [O_3]), particulate matter [PM], carbon monoxide [CO], nitrogen oxides [NO_X], sulfur dioxide [SO_2], and lead [Pb]) (USEPA, 2021). The nearest county out of attainment with a NAAQS is Howard County, TX. Portions of Howard County, TX, were designated as being in non-attainment with the 2010, primary SO_2 NAAQS on April 30, 2021 (USEPA, 2021). Howard County, TX, is located approximately 85 mi. (137 km) east of Lea County, a distance at which air pollution emissions from the proposed EIPC would not be expected to have any noticeable effect on ambient air quality.

Emission sources at the EnergyPlex Park Site would be the same as those described in Subsection 19.4.2.1 for the proposed Eunice site, and air quality impacts would be very similar to those assessed for the proposed Eunice site in Subsection 19.4.2.1. Potential air pollution emissions during construction and decommissioning would include dust from earthmoving and material handling activities, and exhaust emissions from construction equipment and vehicles. Emission-specific control measures, such as watering areas of disturbed soil, would be implemented to limit air quality impacts and ensure compliance with applicable federal and state regulations; thus, air quality impacts associated with facility construction and decommissioning are SMALL.

During facility operation, the occasional testing of the standby diesel generators emits CO, NO_x, and small quantities of PM and SO_2. Emissions during facility operation would be governed by applicable air permits, which would ensure compliance with the NAAQS and other applicable regulatory requirements; thus, air quality impacts associated with facility operation are SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

The IIFP Site is located in Lea County, NM. The ambient air quality in Lea County currently is in attainment with the NAAQS for all criteria pollutants (i.e., O_3, PM, CO, NO_X, SO_2, and Pb) (USEPA, 2021). The nearest county out of attainment with a NAAQS is Howard County, TX. Portions of Howard County, TX, were designated as being in non-attainment with the 2010 primary SO_2 NAAQS on April 30, 2021 (USEPA 2021). Howard County, TX, is located approximately 85 mi. (137 km) east of Lea County, a distance at which air pollution emissions from the proposed EIPC would not be expected to have any noticeable effect on ambient air quality.

Emission sources at the IIFP Site would be the same as those described in Subsection 19.4.2.1 for the Proposed Eunice Site, and air quality impacts would be very similar to those assessed for the Proposed Eunice Site in Subsection 19.4.2.1. Potential air pollution emissions during construction would include dust from earthmoving and material handling activities, and exhaust emissions from construction equipment and vehicles. Emission-specific control measures, such as watering areas of disturbed soil, would be implemented to limit air quality impacts and ensure compliance with applicable federal and state regulations; thus, air quality impacts associated with facility construction are SMALL. Projected air emissions during decommissioning are bounded by the air emissions during construction and is, therefore, considered SMALL.

During facility operation, the occasional testing of the standby diesel generators result in CO and NO_x emissions and emissions of small quantities of PM and SO_2. Emissions during facility operation would be governed by applicable air permits, which would ensure compliance with the NAAQS and other applicable regulatory requirements; thus, air quality impacts associated with facility operation are SMALL.

19.5.2.1.2.3.2 Noise

EnergyPlex Park Site, Hobbs

Noise emissions during construction at the EnergyPlex Park Site would be similar to the emissions described in Subsection 19.4.2.2 for the Proposed Eunice Site. The primary source of noise during construction would be the operation of heavy equipment. Construction-related noise would be noticeable in the immediate construction area, but it would be expected to attenuate to acceptable levels before reaching the site boundary and sensitive receptors. Vehicular traffic due to construction workers commuting to and from the site and deliveries of equipment and supplies to the site would increase noise levels in the immediate vicinity of the site; however, the nearest residence is located more than 2 mi. (3.2 km) from the EnergyPlex site. Therefore, noise impacts associated with construction are SMALL. As noise levels during construction would bound expected noise levels during decommissioning, the noise impacts during decommissioning are expected to be SMALL.

During operation, project-related traffic would be greatly reduced compared to during construction, and there would be no use of heavy construction equipment on the site. As discussed in Subsection 19.4.2.2.2, the only outdoor equipment that produces considerable sound levels are the mechanical-draft cooling towers (MDCTs) needed for the reactor secondary coolant system. The loudest component of MDCT noise is fan discharge, with a noise level of 74 A-weighted decibels (dBA) at 15 m (50 ft.). At the closest residence, this noise level attenuates to below 30 dBA, which is below the typical background noise level for rural

area. (USEPA, 1974). Thus, impacts from on-site noise emissions from the EIPC during operation are SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Noise emissions during construction at the IIFP Site would be similar to the emissions discussed in Subsection 19.4.2.2 for the Proposed Eunice Site. The primary source of noise during construction would be the operation of heavy equipment. Construction-related noise would be noticeable in the immediate construction area, but it would be expected to attenuate to acceptable levels before reaching the site boundary and sensitive receptors. Vehicular traffic due to construction workers commuting to and from the site and deliveries of equipment and supplies to the site would increase noise levels in the immediate vicinity of the site; however, the nearest residence is located more than 1 mi. (1.6 km) from the IIFP site. Therefore, noise impacts associated with construction are SMALL. As noise levels during construction would bound expected noise levels during decommissioning, the noise impacts during decommissioning are expected to be SMALL.

During operation, project-related traffic would be greatly reduced, and there would be no use of heavy construction equipment on the site. As discussed in Subsection 19.4.2.2.2, the only outdoor equipment that produces considerable sound levels are the MDCTs needed for the reactor secondary coolant system. The loudest component of MDCT noise is fan discharge, with a noise level of 74 dBA at 15 m (50 ft.). At the closest residence, this noise level attenuates to below 30 dBA, which is typical background noise level for rural area (USEPA, 1974). Thus, impacts from on-site noise emissions from the EIPC during operation are SMALL.

19.5.2.1.2.4 Geology, Soils, and Seismology Impacts

EnergyPlex Park Site, Hobbs

The EIPC would be located on a greenfield area within the EnergyPlex Park Site boundary consisting of flat terrain with a gentle slope of approximately 0.5 percent. Significant cut and fill is not anticipated except for the topsoil removal and general area grading to construct the facility. The majority of the site is made up of two geographically associated soils. The two main groups are Kimbrough gravelly loam (KO) and the Kimbrough-Lea complex. The upper 10 in. (25 cm) are gravelly loam and the lower 10 – 80 in. (25 – 203 cm) is cemented material (indurated caliche). The soil runoff capacity is high and infiltration capacity is very low. The upper soil layer falls under Hydrologic Soil Group D; however, the presence or absence of "soft" zones in the shallow sedimentary section beneath the site is unknown. Excavation in cemented material for the foundations and pipe trenches is anticipated based on the web soil survey.

The EnergyPlex Park Site is located within the Ogallala formation, which generally consists of sandy caliche and fine- to medium-grained calcareous sand. The depth of caliche varies from 0 – 60 ft. (0.0 – 18.3 m). Depth of calcareous sand varies from 60 – 125 ft. (18.3 – 38.1 m). The specific depth of shallow rock is not available. Existing surface soil at the EnergyPlex Park Site consists of gravelly loam and cemented material to a depth of approximately 80 in. (203 cm) and possibly caliche thereafter, and the possibility of liquefaction is very low. Based on the United States Geological Survey (USGS) karst formation map, this site is located in one of the low probability areas to form karst due to the absence of any carbonate rocks at or near ground surface, and no sinkholes were reported on the site.

There are no active faults that could cause surface rupture within 100 mi. (40.2 km) of the EnergyPlex Park Site. The closest fault to the site is the Guadalupe Fault located west of Carlsbad City, NM, approximately 107 mi. (172.2 km) west of the site. The Guadalupe Fault is classified as fault Class "A" and the slip is less than 0.2 millimeters (mm) per year (yr.) [mm/yr] (0.008 in/yr). Based on the USGS earthquake map, the EnergyPlex Park Site is located in a safe zone with very low probability of having any significant earthquake events. According to the 2018, National Seismic Hazard Model (NSHM), the area has a 2 percent probability of exceedance in 50 years with peak horizontal acceleration between 0.02 g and 0.04 g. According to the U.S. Seismic Design Maps, the site is classified as Class C based on American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) 7-10 design code, Minimum Design Loads for Buildings and Other Structures (ASCE/SEI, 2013), and a Category Risk II.

Based on the information summarized above, there is no indication of unique mineral assets present at the EnergyPlex Park Site that would be impacted by development of the EIPC. Furthermore, no obvious constructability issues are expected at the EnergyPlex Park Site, and there is no indication that contaminated soils are present at the site that would be exposed by site development activities. However, caliche encountered during excavation would have to be removed and replaced with suitable backfill material per geotechnical recommendations for the project.

Based on the information summarized above, geology, soils, and seismology impacts associated with construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site are SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

The EIPC would be located on a greenfield area within the IIFP Site boundary consisting of flat terrain with a gentle slope of approximately 0.1 – 0.5 percent. Significant cut and fill is not anticipated except for the topsoil removal and general area grading to construct the facility. The entire site is made up of two or more geographically associated soils. The two main groups are KO and the Stegall and Slaughter soils. The upper 10 in. (25 cm) are loam and gravelly loam and the lower 10 – 80 in. (25 – 203 cm) is cemented material (indurated caliche). The soil runoff capacity is high and infiltration capacity is very low. The upper soil layer falls under Hydrologic Soil Group D; however, the presence or absence of "soft" zones in the shallow sedimentary section beneath the site is unknown. Excavation in cemented material for the foundations and pipe trenches is anticipated based on the web soil survey.

The IIFP Site is located within the Ogallala formation, which generally consists of sandy caliche and fine- to medium-grained calcareous sand. The depth of caliche varies from 0 – 60 ft. (0.0 – 18.3 m). Depth of calcareous sand varies from 60 – 125 ft. (18.3 – 38.1 m). The specific depth of shallow rock is not available. Existing surface soil at the IIFP Site consists of gravelly loam and cemented material to a depth of approximately 80 in. (203 cm) and probably caliche thereafter. The possibility of liquefaction is very low. Based on the USGS karst formation map, the IIFP Site is located in one of the low probability areas to form karst due to the absence of any carbonate rocks at or near ground surface, and no sinkholes were reported in the vicinity of the project area.

There are no active faults that could cause surface rupture within 25 mi. (40.2 km) of the IIFP Site. The closest fault to the site is Guadalupe Fault located west of Carlsbad City, NM, approximately 110 mi. (177.0 km) west of the site. The Guadalupe Fault is classified as fault Class "A" and the slip is less than 0.2 mm/yr (0.008 in/yr). Based on the USGS earthquake map

the IIFP Site is located in a safe zone with very low probability of having any significant earthquake events. According to 2018, NSHM, the area has a 2 percent probability of exceedance in 50 years with peak horizontal acceleration of 0.02 – 0.04g. According to the U.S. Seismic Design Maps, the site is classified as Class C based on ASCE 7-10 design code and a risk category of II.

Based on the information summarized above, there is no indication of unique mineral assets present at the IIFP Site that would be affected by development of the EIPC. Furthermore, there is no indication that contaminated soils are present at the site that would be exposed by site development activities. Caliche encountered during excavation would need to be removed and replaced with suitable backfill material per geotechnical recommendations for the project.

Based on the information summarized above, geology, soils, and seismology impacts associated with construction, operation, and decommissioning of the EIPC at the IIFP Site are SMALL.

19.5.2.1.2.5 Water Resources Impacts

EnergyPlex Park Site, Hobbs

No rivers, streams, or lakes were identified within the EnergyPlex Park site based on a review of available topographic maps and aerial imagery, and no wetlands were identified within the EnergyPlex Park site boundary based on a review of National Wetlands Inventory (NWI) data. A biological resource survey available for the site noted that no areas surveyed had sufficient wetland indicators to qualify as a wetland, with the exception of a Palustrine Wetland of less than 1 ac. (0.4 ha) (Marron, 2014). However, based on the location of the wetland in proximity to the EnergyPlex Park site, construction and operation of the EIPC are expected to have a low probability of impacting the small wetland mapped within the site boundary.

The High Plains aquifer, also known as the Ogallala aquifer, is a regional aquifer system that underlies the EnergyPlex Park Site. According to the New Mexico Environment Department (NMED) EnviroMap application, the Ogallala aquifer is classified as a sensitive aquifer. However, groundwater depth encountered in the central portion of Lea County, is very deep (i.e., more than 100 ft. [30.5 m]); thus, construction, operation, and decommissioning of the EIPC are expected to have a low probability of impacting groundwater resources.

Based on the current Federal Emergency Management Association floodplain map, the EnergyPlex Park Site location is classified Zone D, as an area of undetermined flood hazard. However, the nearest river is the Pecos River located 56 mi. (90.1 km) west of the site near Artesia, NM, and the elevation difference between river water and the site is approximately 500 ft. (152.4 m). In addition, no upstream dams were identified. Based on the proximity of the EnergyPlex Park Site to surface water features, construction, operation, and decommissioning of the EIPC are expected to have a low probability of impacting floodplains or other surface water resources.

Water use and wastewater discharge associated with the construction and operation of the EIPC at the EnergyPlex Park site would be similar to those described in Section 19.4.4 for the Proposed Eunice Site. All water used at the EIPC during construction, operation, and decommissioning is obtained from the city water supply system, and wastewater discharges are either sent to the local wastewater treatment facility or the on-site evaporation pond. There is no surface water used by the EIPC. Additionally, there is minimal release of water from the facility

to the adjacent environment that impacts surface water systems. Therefore, direct impacts to surface water from water use during plant construction, operation, and decommissioning are SMALL.

Indirect impacts to surface water quality are discussed in Section 19.4.4. Indirect impacts are related to stormwater and pollutant runoff within the project area. Potential indirect surface water quality impacts from facility construction and decommissioning are similar to those of construction for any typical industrial or commercial facility in the area. Erosion and sediment control for ground-disturbing activities meets or exceeds regulatory requirements, including the Clean Water Act National Pollutant Discharge Elimination System requirements.

In accordance with Subsection 19.4.4.1.1.2, an on-site stormwater retention pond located to the west of the EIPC facility structures mitigates adverse impacts of stormwater runoff on-site during plant operation. Stormwater is collected from impervious surfaces, such as buildings, roads, and pads, into the storm sewer system and directed to the stormwater retention pond. The design of the facility, including the construction of a stormwater retention pond, addresses New Mexico regulations for maintaining water quality for 2-year, 24-hour storm events.

As a result, both direct and indirect impacts to surface water are expected to be SMALL for construction, operation, and decommissioning.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

A freshwater pond (approximately 0.66 ac. [0.27 ha]) was identified along the northern portion of the project boundary on the NWI. However, based on location of the pond in proximity to the IIFP Site, construction and operation of the EIPC at the IIFP Site are expected to have a low probability of impact on the small freshwater pond. No other wetlands were identified within the site boundary.

The High Plains aquifer, also known as the Ogallala aquifer, is a regional aquifer system that underlies the IIFP Site. According to the NMED EnviroMap application, the Ogallala aquifer is classified as a sensitive aquifer; however, groundwater depth encountered in the central portion of Lea County, is very deep (i.e., more than 100 ft. [30.5 m]); thus, construction, operation, and decommissioning of the EIPC are expected to have a low probability of impacting groundwater resources.

Water use and wastewater discharge associated with the construction and operation of the EIPC at the IIFP Site would be similar to that described in Section 19.4.4 for the Proposed Eunice Site. All water used at the EIPC during construction, operation, and decommissioning is obtained from the city water supply system, and wastewater discharges are either sent to the local wastewater treatment facility or the evaporation pond. There is no surface water used by the EIPC. Additionally, there is minimal release of water from the facility to the adjacent environment that impacts surface water systems. Therefore, direct impacts to surface water from water use during plant construction, operation, and decommissioning are SMALL.

Similar to the EnergyPlex Park Site evaluation above, the indirect impacts to surface water due to stormwater runoff and pollution control are limited by sediment and erosion control during construction and decommissioning. Indirect impacts due to stormwater runoff during operation are mitigated by the stormwater retention pond located on-site. As a result, indirect impacts associated with stormwater runoff at the IIFP site are SMALL during construction, operation, and decommissioning.

19.5.2.1.2.6 Ecological Resources Impact

EnergyPlex Park Site, Hobbs

Eastern New Mexico, including Lea County, and the EnergyPlex Park site, is characterized as a transitional zone between the shortgrass prairie of the Southern High Plains and the desert communities of the Chihuahuan Desert Scrub. Vegetation in the area is generally dominated by Plains Sand Scrub vegetation communities characterized by the presence of forbs, shrubs, and grasses that are adapted to the deep sand environment that occurs in parts of southeastern New Mexico. Based on a review of aerial imagery, the site generally consists of undeveloped rangelands, and no unique or native habitat was identified within the proposed EnergyPlex Park site boundary. Based on a review of the United States Fish and Wildlife Service (USFWS) Information for Planning and Consulting (IPaC) database and the NM Department of Game & Fish (NMDGF) Biota Information System of New Mexico (BISON-M) database, there is no designated critical habitat located within 1 mi. (1.6 km) of the proposed EnergyPlex Park Site boundary.

No known or documented occurrences of RTE species have specifically been identified within the EnergyPlex Park Site boundary. Based on a review of USFWS species lists and the NMDGF BISON-M database, 24 species are listed within Lea County, of which 2 species are listed as threatened or endangered by USFWS; 8 species are protected by NMDGF; and 35 species are identified by NMDGF as Species of Greatest Conservative Need (SGCN). Listed Federal Threatened and Endangered Species include the Northern Aplomado Falcon.

As described in Subsection 19.4.1.1.1, the total area of permanent disturbance proposed for the EIPC is approximately 55.7 ac. (22.5 ha) of the 800-ac. (324-ha) site available for development. Based on a review of listed species and species range and habitat, it is anticipated that species of concern could occur within the proposed EnergyPlex Park Site boundary. However, potential impacts are expected to be SMALL as no unique or native habitat suitable for threatened or endangered plant or animal species has been identified within the site boundary. Construction, operation, and decommissioning activities are expected to result in limited disturbance of undeveloped rangelands within the site boundary and result in SMALL impacts to migrating birds that use the rangelands to feed.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Eastern New Mexico, including Lea County, and the IIFP site, is characterized as a transitional zone between the shortgrass prairie of the Southern High Plains and the desert communities of the Chihuahuan Desert Scrub. Vegetation in the area is generally dominated by Plains Sand Scrub vegetation communities characterized by the presence of forbs, shrubs, and grasses that are adapted to the deep sand environment that occurs in parts of southeastern New Mexico. Based on a review of aerial imagery, the IIFP Site generally consists of undeveloped rangelands. No unique or native habitat was identified within the IIFP Site boundary. Based on a review of the USFWS IPaC database and the NMDGF BISON-M database, there is no designated critical habitat located within 1 mi. (1.6 km) of the proposed IIFP Site boundary.

No known or documented occurrences of RTE species have specifically been identified within the IIFP site boundary. Based on a review of USFWS species lists and NMDGF BISON-M database, 24 species are listed within Lea County, of which 2 species are listed as threatened or endangered by USFWS; 8 species are protected by NMDGF; and 35 species are identified

by NMDGF as SGCN. Listed Federal Threatened and Endangered Species include the Northern Aplomado Falcon.

As described in Subsection 19.4.1.1.1, the total area of permanent disturbance proposed for the EIPC is approximately 55.7ac. (22.5 ha) of the 200-ac. (81-ha) site available for development. Based on a review of listed species and species range and habitat, it is anticipated that species of concern could occur within the proposed IIFP Site boundary. However, potential impacts are expected to be SMALL as no unique or native habitat suitable for threatened or endangered plant or animal species was identified within the site boundary. Construction, operation, and decommissioning activities are expected to result in limited disturbance of undeveloped rangelands within the site boundary and result in SMALL impacts to migrating birds that use the rangelands to feed.

19.5.2.1.2.7 Historic and Cultural Resource Impacts

EnergyPlex Park Site, Hobbs

There is no indication that previous archeological or cultural resource surveys were conducted at the EnergyPlex Park Site; however, if constructed at the EnergyPlex Park Site, the EIPC would be located in a previously disturbed area (i.e., agricultural) and an area with exposed caliche and no permanent water source. As such, the likelihood of finding new or significant historical, archeological, or cultural resources within the EnergyPlex Park Site is considered SMALL for construction, operation, and decommissioning.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Based on information provided in NUREG-2113, Environmental Impact Statement (EIS) for the Proposed Fluorine Extraction Process and Depleted Uranium Deconversion Plant in Lea County, New Mexico (the EIS for IIFP), a pedestrian survey was completed for the footprint of the 640-ac. (259-ha) IIFP Section. The survey identified three isolated occurrences of cultural resources and noted that a files-check yielded three previous New Mexico Cultural Resources Information System activities, but no previously recorded sites are within 0.62 mi. (1 km) of the project area. The EIS noted that the absence of cultural resources in the site area may be explained by the lack of intermittent or permanent water sources. Given the location of the IIFP Site and the results of the 2012 cultural resource survey, potential impacts to historical, archeological, or cultural resources are expected to be SMALL for construction, operation, and decommissioning.

19.5.2.1.2.8 Socioeconomic Impacts

Socioeconomic impacts associated with the construction and operation of the EIPC at the Proposed Eunice Site are identified and evaluated in Section 19.4.7. The evaluation in Section 19.4.7 includes an assessment of impacts associated with construction and operation of the EIPC, as well as the demands placed on the surrounding region by the construction and operation workforces. As discussed in Section 19.4.7, the socioeconomic impacts of constructing and operating the EIPC at the Proposed Eunice Site are expected to be largely restricted to Lea County, the county in which the site is located, and nearby Andrews and Gaines Counties in Texas. In accordance with the ISG Augmenting NUREG-1537, the socioeconomic impact evaluation of the EIPC considered potential impacts on housing, public services, public education, tax revenues, and transportation.

Both the EnergyPlex Park Site and IIFP Site are located near Routes 483 and 62 in Lea County, west of Hobbs, NM, and south of Lovington, NM (see Figure 19.5.2-1). Both nearby population centers are located in Lea County. Thus, the socioeconomic impacts with either of the two alternative sites are expected to be concentrated in Lea County, NM, and similar in severity to impacts discussed in Section 19.4.7 at the Proposed Eunice Site.

Decommissioning

As noted in Subsection 19.4.7.1.1, the workforce needed for decommissioning the EIPC is smaller than the workforce needed during the construction and operation phases. Therefore, decommissioning has similar but smaller impacts than the construction and operation phases. Thus, impacts to socioeconomics during decommissioning, including housing, public services, public education, taxes, and transportation, are expected to be SMALL.

Housing

Construction and operation workers relocating from outside the region (Lea County) would need to obtain either permanent or temporary housing. Impacts on area housing could happen if the influx of workers is greater than the availability of unoccupied housing units. Additionally, the cost to buy and rent housing could also rise due to the increase in area population. The severity of such effects would largely be determined by the current availability of unoccupied housing units compared to the projected increase in area population.

Per NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants, Revision 0, impacts on housing are considered SMALL if there are few or no easily apparent changes in housing availability and if increases in area rental rates or housing values are equal to or slightly exceed the statewide inflation rate. Impacts are classified as MODERATE if there is found to be a noticeable but short-lived reduction in vacant housing units and area rental rates and housing values rise slightly faster than the statewide inflation rate, but once new housing units become available or project-related demand reduces, and area prices readjust swiftly. LARGE impacts would happen if project-related demand for housing units causes limited housing availability and increases in rental rates and housing values well above regular state inflationary increases.

As noted in Table 19.3.7-6, Lea County has 26,871 housing units, with 4003 vacant housing units available for rent or purchase. As discussed in Subsection 19.4.7.1.1, it is estimated that a maximum of 233 workers are employed at any time for the construction or operation of the EIPC. Based on the methodology provided in Subsection 19.4.7.1.1. it is assumed 30 percent of the construction workforce is from outside the ROI and 40 – 60 percent of the operation workforce migrate from outside the ROI. This results in a maximum in-migration of 79 workers from outside the ROI during construction, operation, and decommissioning. Based on the 4003 vacant housing units in Lea County, the in-migrating workforce occupies 2.0 percent of the vacant housing units, assuming all workers move into Lea County. As such, the housing impact associated with EIPC construction and operation at either of the alternative site locations is SMALL.

Public Services

Lea County, public services include, but are not limited to, water supply and wastewater treatment facilities; police, fire, and medical services; and social services. An increase in area population by EIPC construction and operation workers moving into the region could result in

increased demand for public services. The addition of workers and their families might increase the demand for public services, potentially requiring Lea County, local governments to invest in additional facilities, programs, and staff.

Per NUREG-1437, impacts on public services generally are considered to be SMALL if there is little or no need to add facilities, programs, or staff because of the influx of workers, and MODERATE or LARGE if additional facilities, programs, or staff are required.

As noted in Subsection 19.4.7.1.1, assuming all in-migrating workers move into Lea County, the population increase in Lea County, is 0.3 percent based on 2020 population data. Therefore, even if the entire in-migrating workforce moves into Lea County, the impacts on population from construction, operation, and decommissioning of the EIPC remain SMALL. Based on this minor increase in population, the public services impact associated with construction or operation of the EIPC at either of the alternative sites would be SMALL.

Public Education

Construction and operation workers moving into and bringing any school-aged children into the region neighboring the project site (Lea County) could cause impacts on public education. Any significant growth in the number of school-aged children could cause crowding in local schools, potentially requiring local school systems to invest in additional facilities or staff. Per NUREG-1437, impacts on education are considered to be SMALL if the project-related increase in school enrollment represents less than 3 percent of the total school enrollment in affected school systems and there is no change in the school systems' abilities to provide educational services and if no additional teaching staff or classroom space is needed. Impacts are considered MODERATE if there is a project-related increase in enrollment by 4 – 8 percent, if there is any increase in teaching staff or classroom space, or if there is any change in existing personnel duties. Impacts are considered LARGE if there is more than an 8 percent increase in enrollment or if the enrollment influx can be met only by the addition of new teachers, classrooms, or both.

As noted in Subsection 19.4.7.1.4, assuming all in-migrating families move into Lea County, the student-to-teacher ratio in Lea County increases from 16.8 to 17.0 (approximately 1.2 percent). As the related increase in student-to-teacher ratio is less than 1 and the increase in number of students is less than 3 percent, the impact to education remains SMALL during both construction and operation.

Taxes

State and local jurisdictions would benefit from property taxes and other taxes paid during the construction and operation of the EIPC. According to NUREG-1437, tax impacts are classified as SMALL if project-related tax revenues amount to less than 10 percent of the total tax revenues of the local taxing jurisdictions and the additional revenues provided result in little or no change in local property tax rates and the provision of public services. The impacts are considered to be MODERATE if the additional revenues constitute 10 – 20 percent of the total revenues and if the additional revenues provided result in low property tax levies and increased services by local municipalities. The impacts are considered to be LARGE if project-related tax revenues represent more than 20 percent of the total revenues for local taxing jurisdictions and, if local property tax levies can be lowered substantially, the payment of debt for any substantial infrastructure improvements made in the past can easily be made and future improvements can continue.

Subsection 19.4.7.1.5 provides the EIPC impacts on tax revenue. Included in this review is local tax revenue associated with real estate and sales taxes; state tax revenue, including personal income taxes and the New Mexico Gross Receipts Tax; and federal tax revenue through personal income taxes. Because alternative sites are all located in the same county, Lea County, it is expected that the impacts on local, state, and federal income taxes are the same as the Proposed Eunice Site location. As noted in Subsection 19.4.7.1.5, the impacts on local, state, and federal tax revenues are SMALL and beneficial during both construction and operation. This is expected to be the same at both alternative sites.

Transportation

Transportation adjacent to any of the alternative sites could be affected by the increase in vehicle traffic associated with the delivery of construction materials and equipment to the site and by the commutes of construction and operation workers. The increase in daily traffic could cause congestion and delays within the area. The intensity of such impacts would depend on the current road conditions and typical traffic patterns on the local roads compared with the anticipated increase of construction- and operation-associated traffic.

The two alternative sites are located in rural areas of Lea County. Both the EnergyPlex Park Site and IIFP Site are located along NM-483. As discussed in Subsection 19.4.7.2, construction and operation of the EIPC would result in SMALL transportation impacts due to increased traffic from commuting construction workers; however, both alternative sites are accessible from existing primary state highways and no highway upgrades would be required, with the possible exception of certain safety enhancements, such as the addition of turning lanes. As noted in Subsection 19.4.7.1.1, the estimated number of workers during the construction phase ranges from 26 – 233. The daily commuting workforce plus intermittent equipment mobilization to and from the project site increases traffic relative to current background levels. The annual average daily traffic number of vehicles traveling along NM-483 has increased from 1363 to 2045 from 2018 through 2022. The annual average daily number of commercial vehicles has varied from 77 in 2018 to a peak of 727 in 2019 over the past five years. However, because the expected increase in traffic is considered temporary and would not require installation of additional transportation resources within the area, the transportation impact associated with project construction at either alternative site would be MODERATE during construction.

As discussed in Subsection 19.4.7.1.1, the expected number of workers is 132 during operation and 71 during decommissioning. Most of these vehicles would be associated with commuting operation workers, but it is anticipated that these workers would be divided into three shifts, which would lessen peak facility traffic. As such, the maximum number of vehicles associated with the EIPC during operation would be less than the number of vehicles during the construction phase, and transportation impacts associated with facility operation at either alternative site would be SMALL.

19.5.2.1.2.9 Human Health Impacts

19.5.2.1.2.9.1 Nonradiological Impacts

EnergyPlex Park Site, Hobbs

Potential nonradiological health impacts associated with the construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site would be similar to the impacts described in Subsection 19.4.8.1 for the Proposed Eunice Site with regard to:

- Non-radioactive chemical sources.
- Non-radioactive liquid, gaseous, and solid waste management and control systems.
- Non-radioactive effluents released into the on-site and off-site environment.
- Chemical exposure to the public and on-site workforce.
- Physical occupational hazards.
- Mitigation measures for nonradiological human health impacts.

As discussed in Subsection 19.4.8.1, nonradiological hazardous substances, wastes, effluents and discharges, and occupational hazards associated with the EIPC would be strictly controlled to ensure compliance with applicable federal, state, and local environmental and occupational regulations and standards and the site safety analyses. As such, the nonradiological human health impacts associated with construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site would be SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Potential nonradiological health impacts associated with the construction, operation, and decommissioning of the EIPC at the IIFP Site would be similar to the impacts described in Subsection 19.4.8.1 for the Proposed Eunice Site with regard to:

- Non-radioactive chemical sources.
- Non-radioactive liquid, gaseous, and solid waste management and control systems.
- Non-radioactive effluents released into the on-site and off-site environment.
- Chemical exposure to the public and on-site workforce.
- Physical occupational hazards.
- Mitigation measures for nonradiological human health impacts.

As discussed in Subsection 19.4.8.1, nonradiological hazardous substances, wastes, effluents and discharges, and occupational hazards associated with the EIPC would be strictly controlled to ensure compliance with applicable federal, state, and local environmental and occupational regulations and standards and the site safety analyses. As such, the nonradiological human health impacts associated with construction, operation, and decommissioning of the EIPC at the IIFP Site would be SMALL.

19.5.2.1.2.9.2 Radiological Impacts

EnergyPlex Park Site, Hobbs

The generation of radioactive sources and effluents at the EnergyPlex Park Site would be similar to that described in Subsection 19.4.8.2 for the Proposed Eunice Site. As described for the Proposed Eunice Site, all radiation sources and radioactive effluents would be strictly controlled to ensure compliance with applicable regulations and standards as discussed in Subsection 19.4.8.2. As such, the radiological human health impacts associated with construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site would be SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

The generation of radioactive sources and effluents at the IIFP Site would be similar to that described in Subsection 19.4.8.2 for the Proposed Eunice Site. As described for the Proposed Eunice Site, all radiation sources and radioactive effluents would be strictly controlled to ensure compliance with applicable regulations and standards as discussed in Subsection 19.4.8.2. As such, the radiological human health impacts associated with construction, operation, and decommissioning of the EIPC at the IIFP Site would be SMALL.

19.5.2.1.2.10 Waste Management Impacts

EnergyPlex Park Site, Hobbs

Sources of non-radioactive solid wastes, hazardous wastes, and radioactive wastes generated at the EnergyPlex Park Site would be similar to wastes generated at the Proposed Eunice Site. In addition, waste reuse and minimization programs described for the Proposed Eunice Site would also be implemented at the EnergyPlex Park Site. No conditions have been identified for the EnergyPlex Park Site that would affect waste management impacts as identified in Sections 19.2.7 and 19.2.8. Construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site would be similar to the Proposed Eunice Site with regard to the following factors:

- Sources, types, and approximate quantities of solid, hazardous, radioactive, and mixed wastes.
- Proposed waste management systems designed to collect, store, and process the waste.
- Anticipated waste disposal or waste management plans.
- Anticipated waste-minimization plans to minimize the generation of waste.
- Locations of disposal of all types of waste.

Wastes would be handled, processed, stored, and disposed of as discussed in Sections 19.2.7 and 19.2.8. As such, the waste management impacts associated with construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site would be similar to the waste management impact at the Proposed Eunice Site identified in Section 19.4.9, which is SMALL.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Sources of non-radioactive solid wastes, hazardous wastes, and radioactive wastes generated at the IIFP Site would be similar to wastes generated at the Proposed Eunice Site. In addition, waste reuse and minimization programs described for the Proposed Eunice Site would be implemented at the IIFP Site. No conditions have been identified for the IIFP Site that would affect waste management impacts as identified in Sections 19.2.7 and 19.2.8. Construction, operation, and decommissioning of the EIPC at the IIFP Site would be similar to the Proposed Eunice Site with regard to the following factors:

- Sources, types, and approximate quantities of solid, hazardous, radioactive, and mixed wastes.
- Proposed waste management systems designed to collect, store, and process the waste.

- Anticipated waste disposal or waste management plans.
- Anticipated waste-minimization plans to minimize the generation of waste.
- Locations of disposal of all types of waste.

Wastes would be handled, processed, stored, and disposed of as discussed in Sections 19.2.7 and 19.2.8. As such, the waste management impacts associated with construction, operation, and decommissioning of the EIPC at the IIFP Site would be similar to the waste management impact at the Proposed Eunice Site identified in Section 19.4.9, which is SMALL.

19.5.2.1.2.11 Transportation Impacts

The traffic impacts of vehicles associated with the EnergyPlex Park Site and IIFP Site are discussed in Subsection 19.5.2.1.2.8. This subsection discusses the radiological and other human health impacts of transporting nuclear and non-nuclear materials associated with the project.

No conditions have been discovered that would affect the impacts of transporting nuclear and non-nuclear materials, including radioactive waste, non-radioactive waste, and medical isotopes for either the EnergyPlex Park Site or the IIFP Site. As both alternative sites are also located within Lea County, distance-related impacts of transportation would be similar, as each site would have similar transportation distances to the nearest airport and to the waste disposal facilities. As such, the EIPC located at either the EnergyPlex Park Site or IIFP Site would be similar to the EIPC located at the Proposed Eunice Site as described in Section 19.4.10 with regard to the following factors:

- Transportation modes.
- Approximate transportation distances.
- Treatment and packaging for radioactive and non-radioactive wastes.
- Calculated radiological dose to members of the public and workers from incident-free transportation scenarios.

The transportation impacts associated with construction, operation, and decommissioning of the EIPC at the EnergyPlex Park Site or IIFP Site would be similar to the transportation impacts associated with the Proposed Eunice Site, which are SMALL.

19.5.2.1.2.12 Postulated Accidents Impacts

Postulated accidents associated with the construction, operation, and decommissioning of the EIPC at the Proposed Eunice Site are identified and assessed in Section 19.4.11. The selection of design basis accident (DBA) as well as the bounding Maximum Hypothetical Accident (MHA) is a function of the technology and not related to the location of the site. The evaluation of the MHA for the Proposed Eunice Site computes the total effective dose equivalent and thyroid doses at the site boundary for the MHA in the Reactor Facility and the Hot Cell Facility. Based on the results of the evaluation, it is expected that the radiological dose impact due to postulated accidents is SMALL for the EIPC. These results can be applied to the alternative sites based on the following factors:

- As both alternative sites are located in Lea County, NM, the meteorological conditions that were used to calculate atmospheric dispersion of radiological effluents at the alternative site locations would be the same as those used for the Proposed Eunice Site.
- The EnergyPlex Site property parcel of 800 ac. (324 ha) is significantly larger than the proposed EIPC. As a result, the distance to the property boundary for the EnergyPlex Park Site would be expected to be greater than the Proposed Eunice Site.
- While the IIFP Site property parcel of 200 ac. (80.9 ha) is smaller than the proposed Eunice site property parcel of 240 ac. (97 ha), the expected dose at the property boundary would be expected to be similar to the Proposed Eunice Site and mitigation measures are provided as necessary to maintain dose following a postulated MHA below the limits allowed by 10 CFR 20.301.

As a result, the impacts associated with postulated accidents at either of the alternative sites are SMALL.

19.5.2.1.2.13 Cumulative Impacts

Cumulative impacts include an assessment of any past, present, or reasonably foreseeable future actions that could result in cumulative impacts when combined with the proposed action (40 CFR 1508.7). Actions to be considered in cumulative impact analyses include proposed and continuing activities that are conducted, regulated, or approved by a federal agency or a non-federal entity. The cumulative impacts analysis considers all actions, however minor, because impacts from individually minor actions may be significant when considered collectively over time. The cumulative impact assessment identifies other actions (including related and non-related Federal and non-federal actions) that could contribute to cumulative impacts, such as:

- Information about current or planned local economic development programs or projects (e.g., commercial, industrial, or residential).
- Information about current or planned infrastructure improvements (e.g., transportation, and electric and water utilities).

Past, present, and reasonably foreseeable future development projects and other actions that could result in cumulative impacts at the Proposed Eunice Site and the two alternative sites were identified based on a review of available aerial imagery and a review of Lea County, economic development plans in an effort to identify all relevant activities within a 5-mi. (8-km) radius of each site.

<u>EnergyPlex Park Site, Hobbs</u>

Three electric generating facilities (Xcel Energy Cunningham Station, Xcel Energy Maddox Station, and Lea Power Partners, LLC) are located within 5 mi. (8 km) of the EnergyPlex Park Site. Oil and gas wells, hazardous liquid pipelines, and gas transmission pipelines are also located within 5 mi. (8 km) of the site. No mapped contaminated sites, Superfund sites, or NPL-listed facilities were identified within Lea County, or the vicinity of the EnergyPlex Park Site.

In addition to the electric power generating facilities, other industrial and commercial activities are planned for the EnergyPlex Park complex, including the proposed FEP/DUP being developed by IIFP. Even with the planned development of the EnergyPlex Park complex, it is

anticipated that cumulative impacts from these activities, combined with impacts from the EIPC, if it were located at the EnergyPlex Park Site, would be SMALL with respect to cultural resources and SMALL to MODERATE for land use, air quality, water resources, waste management, and ecological resources. Cumulative impacts would depend on the type of development at the complex and associated environmental resource needs and impacts. In addition, increased industrial activities in the vicinity of the EnergyPlex Park Site could result in increased vehicle traffic and contribute to public resource, housing, and community service impacts in some of the same areas as the EIPC. Therefore, cumulative effects of these projects from increased traffic and socioeconomic impacts are expected to be SMALL to MODERATE as discussed in Subsection 19.5.2.1.2.8, respectively for the EIPC at the EnergyPlex Park Site.

International Isotopes Fluorine Products (IIFP) Site, Hobbs

Three electric generating facilities (Xcel Energy Cunningham Station, Xcel Energy Maddox Station, and Lea Power Partners, LLC) and the DCP Midstream Linam Gas Plant and Clearwater SWD, LLC (an oil and natural gas company) are all located within 5 mi. (8 km) of the IIFP Site. Oil and gas wells, hazardous liquid pipelines, and gas transmission pipelines are also located within 5 mi. (8 km) of the site. No mapped contaminated sites, Superfund sites, or NPL-listed facilities were identified within Lea County, or the vicinity of the IIFP Site.

In addition to the electric power generating facilities, other industrial and commercial activities are planned for the EnergyPlex Park complex, including the proposed FEP/DUP being developed by IIFP. The IIFP Site would be located adjacent to the FEP/DUP facility. Even with the planned development of the EnergyPlex Park complex, it is anticipated that cumulative impacts from these activities, combined with impacts from the EIPC, if it were located at the IIFP Site, would be SMALL with respect to cultural resources and SMALL to MODERATE for land use, air quality, water resources, waste management, and ecological resources. Cumulative impacts would depend on the type of development at the complex and associated environmental resource needs and impacts. In addition, increased industrial activities in the vicinity of the IIFP Park Site could result in increased vehicle traffic and contribute to public resource, housing, and community service impacts in some of the same areas as the EIPC. Therefore, cumulative effects of these projects from increased traffic and socioeconomic impacts are expected to be SMALL to MODERATE as discussed in Subsection 19.5.2.1.2.8 for the EIPC at the IIFP Site.

19.5.2.2 Alternative Technologies

19.5.2.2.1 Identification of Reasonable Alternatives

A proprietary technology is utilized by the EIPC in order to domestically produce medical isotopes such as Mo-99, I-131, Lu-177 and Xe-133. There are three different processes that are being considered to develop the medical isotopes, which are:

- Accelerator-Driven Subcritical Operating Assembly (SHINE Medical Technologies).
- Irradiating a molybdenum-100 (Mo-100) target in a linear accelerator (NorthStar).
- Fission of uranium targets in research reactors (Northwest Medical Isotopes [NWMI]).

Each of these processes represents a technology for producing medical isotopes. However, the linear accelerator-based approach (NorthStar) does not meet the project requirements to also produce isotopes I-131 and Xe-133.

19.5.2.2.2 Evaluation of Reasonable Alternatives

The following subsections explain these alternative technologies in increased detail and assess the possible environmental and socioeconomic impacts associated with construction, operation, and decommissioning of the technologies. Cumulative impacts and potential impact mitigation measures are largely determined by the project site conditions and, therefore, are the same as described for the EIPC.

19.5.2.2.2.1 Accelerator-Driven Subcritical Operating Assembly (SHINE Medical Technologies)

19.5.2.2.2.1.1 Description

The SHINE Medical Technologies facility uses an independent accelerator-driven subcritical operating assembly for the irradiation of an aqueous uranyl sulfate target solution, resulting in the production of Mo-99 and other fission products.

19.5.2.2.2.1.2 Land Use and Visual Resources Impact

The SHINE facility sited in Janesville, Wisconsin, consists of 91.27 ac. (36.94 ha). This site is smaller than the Proposed Eunice Site, which consists of a 245.6 ac. (99,4 ha) project area, including easement. The SHINE facility would permanently disturb 25.67 ac. (10.39 ha) due to construction, operation, and decommissioning of the facility. An additional 14 ac. (5.7 ha) would be temporarily disturbed to support construction activities (SHINE, 2015). Thus, the impacts on land use associated with the SHINE technology are less than the EIPC as described in Subsection 19.4.1.1.1, which are considered SMALL.

The SHINE production facility is 86 ft. (26 m) high, which is significantly higher than the EMIF height of 42 ft. (12.8 m) (SHINE, 2015). However, as noted in Subsection 19.4.1.2, the viewshed to the east of the proposed EIPC consists of pastureland and the Lea County Landfill and to the northeast, the URENCO facility. To the south and west, the viewshed is primarily pastureland. Because the viewshed to the northeast and east includes major industrial and commercial facilities, the addition of a facility with the SHINE design does not significantly alter visual setting and impacts to visual setting from construction, operation, and decommissioning of the SHINE facility are SMALL.

19.5.2.2.2.1.3 Air Quality and Noise Impacts

Air emissions during construction for the SHINE facility are essentially the same as for the EIPC. Fugitive dust emissions due to earthmoving equipment and construction traffic, etc., are expected for any major construction activity and are applicable regardless of the technology. Best management practices (BMPs), such as stabilizing construction roads and spoil piles, limiting speeds on unpaved roads, watering unpaved roads, and general good housekeeping, can limit fugitive dust emissions during construction, resulting in SMALL impacts to air quality.

During operation, air emissions and gaseous effluents result from both isotope production and fuel combustion. Based on an evaluation provided in the SHINE Preliminary Safety Analysis Report Subsection 19.4.2.1.2.2.4.3, no impacts exceed the primary ambient air quality standards that have been established to protect public health, including the health of sensitive populations such as children, the elderly, and those with respiratory ailments. (SHINE 2015)

Therefore, pollutant impacts within a reasonable area that could be impacted and at points of the maximum individual exposure are SMALL.

During the decommissioning phase, activities, equipment usage, and their associated emissions are expected to be similar, but less than that of the construction phase. Therefore, impacts during the decommissioning phase are SMALL.

During construction, on-site noise level exposure would be controlled through appropriate training, personal protective equipment (PPE), periodic health and safety monitoring, and industry best practices. Practices such as maintenance of noise-limiting devices on vehicles and equipment, controlling access to high-noise areas, limiting duration of noise-producing activities, and possibly shielding high-noise sources near their origin limit the adverse effects of noise on workers. Non-routing activities with potential adverse impacts on noise levels are limited through the use of best industry practices that further limit adverse effects. As a result, noise impacts during construction are SMALL. During decommissioning, the sources of noise, such as from earthmoving equipment, are similar to the construction phase. Therefore, noise impacts during the decommissioning phase are SMALL.

External noise emission from the SHINE facility during operation is primarily limited by the walls and other physical barriers of the facility itself (SHINE 2015). As SHINE does not have MDCTs, the noise impacts during operation would be less than that for the EIPC. Therefore, noise impacts during operation are SMALL.

19.5.2.2.2.1.4 Geology, Soils, and Seismology Impacts

The seismic and geologic hazards are a function of the site geology and not a function of the technology used. The SHINE facility construction requires some excavation, as well as the utilization of some geologic resources as fill material. The expected excavation for the SHINE facility is 39 ft. (11.9 m) below grade (SHINE 2015). This depth is similar to the EIPC Reactor Facility excavation depth of 35 ft. (10.7 m), as noted in Table 19.4.3-1. Any new facility is expected to be designed and constructed to minimize the geology, soils, and seismology impacts such that the impacts during the construction and operation phases would be SMALL. Geological impacts during decommissioning are bounded by construction activities and are therefore considered SMALL.

19.5.2.2.2.1.5 Water Resources Impacts

Construction of the SHINE facility, as well as its associated parking and roadways, would result in a potential increase in stormwater runoff from the project site similar to the EIPC construction impacts. Sediment and erosion control BMPs would be employed to mitigate the potential indirect impacts associated with the release of sediment or other runoff constituents to off-site areas. Water requirements for the SHINE facility operation are less than the EIPC due to the lack of MDCTs in the SHINE facility design. All required water would be obtained from municipal supplies, and all wastewater discharges would go to a municipal sewer system. Furthermore, it is not anticipated that construction, operation, or decommissioning of the facility would require direct withdrawals of local groundwater. Consequently, impacts to water resources would be less than those described for the EIPC in Section 19.4.4, and the impact to water resources during construction and operation would be SMALL.

Water resources impacts during decommissioning would be similar to those during construction and mostly related to stormwater runoff. As a result, water resources impacts during decommissioning are bounded by construction and are considered SMALL.

19.5.2.2.2.1.6 Ecological Resources Impact

The SHINE facility converts 25.7 ac. (10.4 ha) of land to industrial facilities (SHINE 2015). This is less than the EIPC footprint, which converts 55.7 ac. (22.5 ha) for industrial facilities and infrastructure. As a result, the ecological resource impacts from the construction, operation, and decommissioning of the SHINE facility are expected to be smaller than those described in Section 19.4.5 for the EIPC. Because the ecological impacts of the EIPC are SMALL, the expected ecological impacts for the SHINE facility at the Proposed Eunice Site location during construction, operation, and decommissioning are SMALL.

19.5.2.2.2.1.7 Historic and Cultural Resources Impact

As noted in the above subsection, the amount of land required for the SHINE facility is less than that required by the EIPC; therefore, the historical and cultural resource impacts are expected to be similar to or less than those described in Section 19.4.6 for the EIPC. As a result, impacts to historical and cultural resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.1.8 Socioeconomic Impacts

Construction of the SHINE facility would have a beneficial impact on area employment and tax revenues. The facility's operation would generate approximately 150 jobs, with a peak employment of 451 workers during construction per NUREG-2183, Environmental Impact Statement for the Construction Permit for the SHINE Medical Radioisotope Production Facility, in addition to providing additional tax revenues and alleviating medical isotope shortages. These positive impacts, as well as possible impacts on area public services and transportation, would be comparable to those described for the EIPC in Section 19.4.7. Therefore, the socioeconomic impacts during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.1.9 Human Health Impacts

Construction of the SHINE facility would involve possible risks to workers typical of any construction site. Normal construction safety procedures would be instituted to promote worker safety and reduce the likelihood of worker injury during construction. Nonetheless, construction accidents could occur.

Air emissions from the facility have the potential to contain radiological material. The gaseous effluents, which consist of the noble gases, krypton and xenon, in addition to iodine and tritium, would be released to the environment through the production facility building vent stack. Prior to release to the environment, gaseous effluents would be held up to allow for decay. Based on the results of the dose analysis prepared by SHINE, radiological impacts to members of the public due to operation of the SHINE facility are SMALL.

The fixed sources of radiation include the production building, which contains sources created during production operations with the Radiation Control Area, and the waste staging and shipping building, which contains sources associated with staging of solidified radioactive waste prior to shipment off-site. (SHINE 2015) Exposure minimization would be achieved through both

engineered and administrative controls. Worker monitoring would be performed to ensure occupational dose remains at or below 10 CFR Part 20 regulatory limits. Thus, the radiological human health impacts of construction. operation, and decommissioning are SMALL.

Nonradiological hazards are associated with emissions, discharges, and wastes from processes within the facility, as well as accidental spills and releases. Non-radioactive wastes generated by construction, operation, and decommissioning of the new plant, including solid wastes, liquid waste discharges and air emissions, would be managed in accordance with applicable federal, state, and local laws and regulations, and applicable permit requirements. As a result, the impact of nonradiological hazards on human health is SMALL for construction, operation, and decommissioning.

19.5.2.2.2.1.10 Waste Management

SHINE facility wastes would be managed in accordance with applicable Federal, state, and local regulations. As a result, the direct impacts to the environment from transportation and delivery of waste would be SMALL. In addition, the indirect impacts to the environment from transportation and delivery of waste to off-site waste repositories would be SMALL.

19.5.2.2.2.1.11 Transportation Impacts

Nuclear materials would be transported to and from the SHINE facility. The nuclear materials transported to the SHINE facility would consist of LEU metal and tritium. The nuclear materials transported from the SHINE facility would consist of generated medical isotopes Mo-99, I-131, and Xe-133, and the radioactive wastes generated during production of the medical isotopes (SHINE 2015).

The LEU metal would be transported by truck to the SHINE facility. The radioactive wastes would be transported by truck to various disposal facilities. The medical isotopes produced at the SHINE facility would be transported by air to the various facilities for final processing and distribution to medical facilities. Transportation by truck would be used as a backup in cases where inclement weather does not allow for air delivery. The transportation routes associated with transporting the medical isotopes from and the LEU metal to the facility, as well as transportation routes for the LLW to the LLW waste disposal site, would be the same routes identified in Section 19.4.10 for the EIPC. Prior to shipment, all radioactive material would be packaged to meet U.S. Department of Transportation and NRC requirements for the transportation of radioactive materials.

The incident-free radiological doses were determined for members of the public and the workers that would be involved with the transportation of the medical isotopes and the radioactive wastes (transportation and handling workers). Compared with the background dose in the vicinity, the effect of incident-free transportation from the SHINE facility would be SMALL.

19.5.2.2.2.1.12 Postulated Accidents Impacts

The postulated initiating events and credible accidents were determined and evaluated for the SHINE facility in accordance with final ISG Augmenting NUREG-1537. The MHA was determined to be the event that results in radiological consequences that exceed those of any fission product accident considered credible. The MHA therefore bounds the radiological consequences of postulated DBA scenarios at the SHINE facility. The MHA is used to demonstrate that the maximum consequences of a fission product release accident at the

SHINE facility would be within the acceptable regulatory limits of 10 CFR 20.1301. The MHA assumed a failure that resulted in a radioactive release with radiological consequences that bound all credible DBAs. Based on the results of the MHA analysis, the released dose is less than the dose criteria in 10 CFR 20.1301. (SHINE 2015) Thus, the impact of the postulated accidents is considered to be SMALL.

19.5.2.2.2.2 Irradiation of Mo-100 Target in Linear Accelerator (NorthStar)

19.5.2.2.2.2.1 Description

Multiple linear accelerators are utilized by this technology in order to produce Mo-99. Electrons are accelerated by the linear accelerator before colliding with a metal target to produce high-energy photons. A target made of Mo-100 is irradiated by the high-energy photons, producing Mo-99. The Mo-99 is delivered to pharmacies for TechneGen™ processing, as well as Tc-99m generation. The design allows production to be increased as required by demand.

19.5.2.2.2.2.2 Land Use and Visual Resources Impact

The NorthStar facility is located on a project site of 33 ac. (13.4 ha), of which half of the area is permanently disturbed for the production facility, road access, and other improvements (DOE 2012). As the facility is smaller in size than the SHINE, it would require less land use compared with that of the EIPC facility. As a result, the land use impact for the NorthStar facility would be SMALL for construction, operation, and decommissioning.

The tallest structure is the emission stack for the chemical processing area, which is 60 ft. (18 m) tall and 2 ft. (0.6 m) in diameter (DOE 2012), which is larger than the EMIF height of 42 ft. (12.8 m). However, as noted in Subsection 19.4.1.2, the viewshed to the east consists of pastureland and the Lea County Landfill and to the northeast the URENCO facility. To the south and west, the viewshed is primarily pastureland. Because the viewshed to the northeast and east includes major industrial and commercial facilities, the addition of a facility with the NorthStar design does not significantly alter visual setting and impacts to visual setting from construction, operation, and decommissioning of the NorthStar facility are SMALL.

19.5.2.2.2.2.3 Air Quality and Noise Impacts

Air emissions during construction for the NorthStar facility are essentially the same as for the EIPC. Fugitive dust emissions due to earthmoving equipment and construction traffic, etc., are expected for any major construction activity and are applicable regardless of the technology. BMPs such as stabilizing construction roads and spoil piles, limiting speeds on unpaved roads, watering unpaved roads, and general good housekeeping can limit fugitive dust emissions during construction, resulting in SMALL impacts to air quality.

Air emissions would be expected from operation of the building's heating system. Process emissions would not be anticipated, but the chemicals used to dissolve Mo-99 targets and the resulting evaporation may produce small emissions. Operation emissions under this technology would not be expected to expose sensitive receptors to increased pollution or exceed any federal or state air quality standard.

Additionally, the facility's operation would generate an increase in vehicular emissions and noise as a result of shipping radioisotopes, as well as from operating and maintaining the facility. The operation of both linear accelerator and chemical processing equipment would produce noise.

While considerable noise is expected to be generated during operation, the noise would be contained within the facility and no impact is anticipated on the surrounding ambient noise levels. It is expected that BMPs, such as hearing protection in high-noise areas, would be utilized to limit exposure below permissible levels defined by the Occupational Safety and Health Administration. The NorthStar technology uses outdoor air-cooled heat exchangers to provide the necessary process cooling. Based on the NorthStar Environmental Assessment, the noise from the fans does not exceed 60 dBA at a distance of 30 ft. (9 m) (DOE, 2012). This is lower than the estimated fan noise from the EIPC MDCTs. Thus, the air quality and noise impacts during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.4 Geology, Soils, and Seismology Impacts

Regardless of technology, the facility would be planned to endure seismic and geologic hazards equivalent to the EIPC. Construction of this technology would require some excavation, as well as the utilization of some geologic resources as fill material. The depth of excavation for the NorthStar facility subbasement is up to 30 ft. (9 m) (DOE, 2012). This is similar to the depth of excavation required for the Reactor Facility portion of the EMIF identified in Table 19.4.3-1 of 35 ft. (10.7 m). It is expected that any new facility would be designed and constructed to minimize the geology, soils, and seismology impacts such that the impacts during the construction, operation, and decommissioning phases would be SMALL.

19.5.2.2.2.2.5 Water Resources Impacts

Construction of the proposed facility, as well as its associated parking and roadways would potentially increase stormwater runoff from the project site in comparison to the site's undeveloped state. However, it is anticipated that sediment and erosion control BMPs would be employed to mitigate the potential indirect impacts associated with the release of sediment or other runoff constituents to off-site areas. As all required water would be obtained from municipal supplies, it would not be anticipated for facility operation to require direct withdrawals of local groundwater. The cooling system for the NorthStar technology uses a hybrid system that augments the air-cooled heat exchangers with evaporative cooling during summer plant operating conditions (DOE, 2012). As a result, the water use for the NorthStar technology is expected to be less than that of the EIPC, which utilizes evaporative cooling through MDCTs as the main heat dissipation system for the reactor. The impacts to water resources would be similar to, or less than, those described for the EIPC in Section 19.4.4. Therefore, the impacts to water resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.6 Ecological Resources Impact

The size of this facility (33 ac. [13 ha]) is smaller than the size of the EIPC; therefore, the ecological resource impacts are expected to be similar to those described in Section 19.4.5 for the EIPC. Therefore, the impacts to ecological resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.7 Historic and Cultural Resources Impact

The size of this facility is smaller than the EIPC; therefore, the historical and cultural resource impacts are expected to be similar to those described in Section 19.4.6 for the EIPC. Therefore, the impacts to historical and cultural resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.8 Socioeconomic Impacts

Construction of the facility would have a beneficial impact on area employment and tax revenues. The facility's operation would generate approximately 150 jobs and a range of 5 – 50 on-site workers during construction (DOE, 2012), in addition to providing additional tax revenues and alleviating medical isotope shortages. These positive impacts, as well as possible impacts on area public services and transportation, would be comparable to those described for the EIPC in Section 19.4.7. Therefore, the socioeconomic impacts during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.9 Human Health Impacts

Construction would involve potential hazards to workers typically expected in any construction site. Worker safety would be promoted and the likelihood of worker injury during construction would be reduced via the implementation of normal construction safety practices. Nonetheless, construction accidents could occur.

Air emissions from the facility would potentially contain radiological material due to the accelerator operation, as well as the dissolution and packaging of radioactive materials in the hot cells. However, the facility design and operation would be planned with the intention that the amount of radioactive material released would be controlled to a negligible amount. During operation, any liquid waste generated would be collected and stored on-site temporarily before being sent off-site for treatment and disposal. No radioactive material would be released from the proposed facility through wastewater. No public dose would be projected to be produced from air emissions or wastewater. Radiological emissions would not be anticipated; regardless, impacts on the public would be negligible in the event that any emissions were to occur.

The potential worker exposure sources include the activities accompanying the linear accelerator irradiation of the Mo-100 targets, transfer of irradiated material into the hot cells, packaging and shipment of the Mo-99 products, and preparation of any radioactive waste for disposal. Several features would be included in the Mo-99 production facility design and operation in order to limit worker dose. It is anticipated that only a fraction of the Mo-99 production facility's workers would receive any radiation dose; individual worker doses would not exceed the 5 rem per year regulatory limit. The impacts to human health during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.2.10 Waste Management Impacts

NorthStar facility wastes would be managed in accordance with applicable federal, state, and local regulations. As a result, the direct impacts to the environment from transportation and delivery of waste would be SMALL. In addition, the indirect impacts to the environment from transportation and delivery of waste to off-site waste repositories would be SMALL. This is applicable to all phases of construction, operation, and decommissioning.

19.5.2.2.2.2.11 Transportation Impacts

LLW would be shipped by truck to waste disposal facilities, and Mo-99 would be shipped by air for processing. The transportation impacts would be similar or less (because there would be no fission product wastes) than those for the EIPC facility discussed in Section 19.4.10. Therefore, the transportation impacts would be SMALL.

19.5.2.2.2.2.12 Postulated Accidents Impacts

As discussed in the Environmental Assessment for NorthStar, a variety of accidents concerning radioactive Mo-99 or chemicals to be used in the process was postulated. Most postulated accidents projected that risks to the public would be SMALL (DOE, 2012). Impacts of extremely unlikely severe accidents, such as building collapse from an earthquake or explosion, could extend to members of the public. A severe accident triggering release of the entire helium inventory (from the target-cooling system) could result in dispersion of hazardous concentrations extending about 280 ft. (85 m) from the building; the distance from the building to the site boundary is 66 ft. (20 m). A severe accident involving direct exposure to a freshly irradiated molybdenum target would result in a risk of latent cancer fatality of $7x10^{-4}$ (1 chance in 1400) to someone exposed at the site boundary for one hour (DOE, 2012).

The evaluation of postulated accidents provided in the environmental assessment is bounding for the NorthStar technology at the Proposed Eunice Site location. As noted in Subsection 19.5.2.2.2.2.2, the NorthStar facility project site area is 33 ac. (13.4 ha), of which approximately half of this area is disturbed for facilities and infrastructure; this is significantly less than the project area at the Proposed Eunice Site location of 245.6 ac. (99.4 ha). As a result, the distance from the facility to the property line for the NorthStar facility located at the Proposed Eunice Site would be expected to be greater than the distance to the property line assumed in the NorthStar environmental assessment. As a result, the impact of postulated accidents for the NorthStar technology at the Proposed Eunice Site location would be SMALL for construction, operation, and decommissioning.

19.5.2.2.2.3 Fission of Uranium Targets in Research Reactors (NWMI)

19.5.2.2.2.3.1 Description

Prior to CP termination, NWMI developed a radioisotope production facility (RPF) to process LEU targets irradiated in research reactors through a fission-based process. The RPF houses the entire production process, which includes (NWMI, 2021):

- Receiving LEU from the DOE.
- Producing LEU target materials and fabrication of targets.
- Packaging and shipping LEU targets to the university research reactor network for irradiation.
- Returning irradiated LEU targets to NWMI for dissolution, recovery, and purification of Mo-99.
- Packaging Mo-99 product to prepare for transport to radiopharmaceutical generator manufacturers.
- Recovering and recycling LEU to fabricate new targets to minimize radioactive, mixed, and hazardous waste generation.
- Treating and packaging wastes generated by the RPF process steps and preparing for transport and disposal.
- NWMI facility only processes LEU targets that have been irradiated at separate research reactors. The research reactors are not included as part of the alternative technology review. However, it is recognized that additional environmental impacts would occur if

both the medical isotope processing facility and research reactors are included in this review. These environmental impacts are conservatively not included as part of the alternative technology review below.

19.5.2.2.2.3.2 Land Use and Visual Resources Impact

Impacts to land use are related to the amount of land disturbed and the type of construction on the land. The RPF would be approximately 350 x 185 ft. (106.7 x 56.4 m) and would stand 65 ft. (19.8 m) tall above grade. The actual RPF building would occupy a rectangular area approximately 700 x 300 ft. (213 x 91 m) at the outer perimeter and cover approximately 4.8 ac. (1.95 ha). The overall land use is less than the proposed land use at the EIPC, which converts 55.7 ac. (22.5 ha) of undeveloped scrub/shrub to industrial facilities (Subsection 19.4.1.1.1). Thus, the land use impacts are expected to be less than that for the EIPC and would be considered SMALL for construction, operation, and decommissioning.

At its tallest point, the RFP's exhaust stacks, at 75 ft. (22.9 m) total height and 10 ft. (3 m) above the roof level, would be the facility's tallest fixed feature viewable from a distance (NWMI, 2013). However, as noted in Subsection 19.4.1.2, the viewshed to the east consists of pastureland and the Lea County Landfill and to the northeast the URENCO facility. Because the viewshed to the northeast and east includes major industrial and commercial facilities, the addition of a facility with the NWMI design does not significantly alter visual setting and impacts to visual setting from construction, operation, and decommissioning of the NWMI facility are SMALL.

19.5.2.2.2.3.3 Air Quality and Noise Impacts

Air emissions during construction and decommissioning for the NWMI facility are essentially the same as for the EIPC. Fugitive dust emissions due to earthmoving equipment and construction traffic, etc., are expected for any major construction activity and are applicable regardless of the technology. BMPs such as stabilizing construction roads and spoil piles, limiting speeds on unpaved roads, watering unpaved roads, and general good housekeeping can limit fugitive dust emissions during construction and decommissioning, resulting in SMALL impacts to air quality.

Operation activities may result in a slight increase in vehicle traffic in the immediate area of the RPF, which could cause a slight increase in internal combustion emissions, such as CO, NO_x, and, to a lesser extent, SO_2. Operation of the emergency standby generator would also result in a slight increase in emission products, but due to intermittent use, these emissions would be low. The majority of effluent would be from radioisotope production and the release of a small amount of gaseous fission products. The offgas system would be designed to filter and retain these isotopes in the facility until they are less than the established allowable concentrations for residential receptors. The resulting release would be maintained until levels are less than those defined in Table 2 of 10 CFR Part 20, Appendix B. No pollutant to be released during normal RPF operation is estimated to exceed NAAQS (NWMI, 2013). Therefore, the impact of plant operation on air quality would be SMALL.

Noise impacts during construction and decommissioning would be expected to be similar to EIPC construction. During facility operation, noise sources include vehicles due to shipping radioisotopes, as well as facility operation and maintenance. Noise sources from operating and maintaining the facility would be expected to be contained within the production facility and would not be expected to significantly impact ambient noise levels. Therefore, the facility impact on noise would be expected to be SMALL.

19.5.2.2.2.3.4 Geology, Soils, and Seismology Impacts

Regardless of technology, the facility would be planned to endure seismic and geologic hazards equivalent to the EIPC. Construction of this technology would require some excavation, as well as the utilization of some geologic resources as fill material. It is expected that any new facility would be designed and constructed to minimize the geology, soils, and seismology impacts such that the impacts during construction, operation, and decommissioning phases would be SMALL.

19.5.2.2.2.3.5 Water Resource Impacts

Construction of the RPF facility, as well as its associated parking and roadways would potentially increase stormwater runoff from the project site in comparison to the site's undeveloped state; however, it is anticipated that sediment and erosion control BMPs would be employed to mitigate the potential indirect impacts associated with the release of sediment or other runoff constituents to off-site areas. As all water required for facility operation would be obtained from municipal supplies, it would not be anticipated for facility operation to require direct withdrawals of local groundwater. The impacts to water resources would be similar to, or less than, those described for the EIPC in Section 19.4.4. Therefore, the impacts to water resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.3.6 Ecological Resources Impact

As noted in Subsection 19.5.2.2.2.3.2, this facility is smaller in size compared with the EIPC. As such, the impacts to ecological resources would be similar to those caused by the EIPC, as described in Section 19.4.5. Therefore, the impacts to ecological resources during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.3.7 Historic and Cultural Resources Impact

This facility is smaller in size compared with the EIPC. As such, the impacts to historical and cultural resources would be similar to those described in Section 19.4.6 for the EIPC. Therefore, the historical and cultural impacts during construction, operation, and decommissioning phases would be SMALL.

19.5.2.2.2.3.8 Socioeconomic Impacts

Construction of the RPF facility would have a beneficial impact on area employment and tax revenues. The facility's operation would generate approximately 98 jobs, in addition to providing additional tax revenues, and alleviate shortages of medical isotopes (NWMI, 2013). These positive impacts, as well as possible impacts on area public services and transportation, would be comparable to those described for the EIPC in Section 19.4.7. Therefore, the socioeconomic impacts during construction, operation, and decommissioning would be SMALL.

19.5.2.2.2.3.9 Human Health Impacts

Construction would involve potential hazards to workers typically expected in any construction site. Worker safety would be promoted and the likelihood of worker injury during construction would be reduced via the implementation of normal construction safety practices. Potential hazards during decommissioning would be similar to those during construction. Safety

precautions and practices would reduce the likelihood of worker injury during decommissioning. As a result, human health impacts during construction and decommissioning would be SMALL.

Potential nonradiological public and occupational hazards pertaining to the operation of the RPF are associated with emissions, discharges, and waste resulting from the processes within the facility, and from accidental spills and releases. Typical occupational hazards associated with work conducted in a process facility would be expected. These hazards include lighting, noise, repetitive motion, awkward posture, sharp objects, and slips, trips, and falls. Mitigation measures, including workplace and environmental regulations, would be used to ensure the protection of human health. BMPs would be employed during construction, operation, and decommissioning to minimize pollutant releases to on-site and off-site areas, ensure delivery of all facility wastewater to the local municipal wastewater treatment facility, and impose air emission controls, as appropriate. Waste reduction practices, including recycling and waste minimization, would also be employed. (NWMI, 2013). As a result, the nonradiological impacts on human health would be SMALL.

The RPF could release small quantities of radionuclides to the environment. Gaseous effluent activity releases and liquid effluent activity releases would be managed to ensure compliance with applicable federal, state, and local requirements. Direct dose to a member of the public at the fenceline would be due to gamma radiation penetrating the walls of the production facility and the waste staging and shipping area. The facility and facility systems would be designed to ensure that any dose at the fenceline would be below applicable limits. Administrative dose limits are occupational radiation exposure limits that radiation workers at the RPF would not exceed without prior management approval. Administrative controls would be used to ensure that workers do not receive dose above regulatory limits (NWMI, 2013). As a result, the radiological impact on human health would be expected to be SMALL.

19.5.2.2.2.3.10 Waste Management Impacts

The waste management system consists of on-site treatment and waste minimization approaches, as well as anticipated disposal locations. The facility waste types would be managed in accordance with applicable federal, state, and local regulations. As a result, the direct and indirect impacts associated with the treatment and disposal of RPF-generated wastes would be SMALL during construction, operation, and decommissioning.

19.5.2.2.2.3.11 Transportation Impacts

Materials that would be transported to the RPF include LEU, irradiated targets, process chemicals, and other industrial supplies to support day-to-day operation of the facility. Materials transported from the RPF would include Mo-99 product, targets, spent LEU, and waste. Compared to the background doses in the vicinity of the RPF, the effect of incident-free transportation would be SMALL during construction, operation, and decommissioning.

19.5.2.2.2.3.12 Postulated Accidents Impacts

The RPF would be constructed, operated, and decommissioned to ensure that the consequences of postulated accidents would be compliant with applicable regulations and standards. Therefore, the postulated accident impacts during the construction, operation, or decommissioning phases associated with the RPF would be SMALL.

Table 19.5.2-1
(Sheet 1 of 2)
Site Evaluation Scores

Evaluation Criteria		Weight	EnergyPlex Park Site		Proposed Eunice Site		IIFP Site	
No.	Description		Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
A.	Local Infrastructure and Utilities							
1	Site Utilities	8	2	16	4	32	2	16
2	Highway Access	8	3	24	5	40	4	32
3	Airport Access	10	5	50	3	30	5	50
4	Access to Emergency Health Care	6	3	18	2	12	3	18
5	Distance to LLEA	8	2	16	4	32	3	24
B.	Site Development, Constructability, Seismic, and Geotechnical							
1	Site Size and Topography	6	5	30	5	30	5	30
2	Foundation, Earthwork, and Pipe Installation Conditions	6	2	12	3	18	2	12
3	Shallow Rock	5	3	15	3	15	3	15
4	Groundwater Conditions	5	5	25	5	25	5	25
5	Flood Protection	5	5	25	5	25	5	25
6	Constructability, Existing Structures, and Undergrounds	6	5	30	5	30	3	18
7	Aircraft Hazards	8	1	8	3	24	2	16
8	Proximity to Active and Inactive Faults	9	4	36	4	36	4	36
9	Seismic Hazards	8	5	40	5	40	5	40
10	Settlement and Liquefaction Potential	7	4	28	4	28	4	28
11	Karst, Sinkholes, and Subsidence	7	5	35	5	35	5	35

Table 19.5.2-1
(Sheet 2 of 2)
Site Evaluation Scores

Evaluation Criteria		Weight	EnergyPlex Park Site		Proposed Eunice Site		IIFP Site	
No.	Description		Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
C.	Environmental and Natural Resources							
1	RTE Species	9	3	27	3	27	3	27
2	Designated Critical Habitat	8	5	40	5	40	5	40
3	On-Site Natural Habitats	5	4	20	4	20	4	20
4	Surface Water Resources and Waters of the U.S.	7	2	14	5	35	4	28
5	Regional Air Resources	5	5	25	5	25	5	25
6	Proximity to Natural Areas	6	2	12	3	18	4	24
7	Groundwater and Drinking Water Resources	8	1	8	1	8	1	8
8	Prime Farmland	5	4	20	1	5	4	20
9	Proximity to Hazardous Land Uses	6	3	18	1	6	3	18
10	Proximity to Contaminated Properties	6	5	30	5	30	2	12
D.	Land Use, Socioeconomics, and Community Acceptance							
1	Existing On-Site Land Use	8	3	24	3	24	3	24
2	Existing Land Use within 1 mi. of the Site	7	5	35	5	35	5	35
3	Zoning and Land Use Planning	6	5	30	5	30	5	30
4	Parks and Recreation	7	5	35	5	35	5	35
5	Historic and Cultural Resources	8	5	40	5	40	5	40
6	Aesthetic and Noise Impacts	7	5	35	5	35	5	35
7	Environmental Justice	7	2	14	4	28	2	14
8	Existing Nuclear Infrastructure – Public Acceptance	5	3	15	3	15	3	15
9	Political Support and Financial Incentives	7	5	35	5	35	5	35

Abbreviations: No. = number | IIFP = International Isotopes Fluorine Products, Inc. | LLEA = Local Law Enforcement Agency | RTE = Rare, Threatened, and Endangered | U.S. = United States | mi. = mile(s)

Table 19.5.2-2
Site Evaluation Results

Category	Category Description	Total Weight	EnergyPlex Park Site		Proposed Eunice Site		IIFP Site	
			Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
A.	Local Infrastructure and Utilities	40	15	124	18	146	17	140
B.	Site Development, Constructability, Seismic, and Geotechnical	72	44	284	47	306	43	280
C.	Environmental and Natural Resources	65	34	214	33	214	35	222
D.	Land Use, Socioeconomics, and Community Acceptance	62	38	263	40	277	38	263
	Total, Raw, and Weighted Scores	1195	131	885	138	943	133	905
	Percent of Total Possible Weighted Score			74%		79%		76%

Abbreviations: IIFP = International Isotopes Fluorine Products, Inc.

19.5.3 COST BENEFIT OF ALTERNATIVES

This subsection presents the costs and benefits of the proposed action along with each reasonable alternative site and technology. For each alternative and proposed action, the following costs are described:

- Environmental degradation (e.g., impacts to air and water quality; biotic resources; and aesthetics, as well as socioeconomic impacts, such as noise, traffic congestion, increased demand for public services, and land use changes).
- Effects on public health and safety.
- Other costs (e.g., unrealized tax revenue, decreased recreational value, and lack of improvement to transportation and infrastructure, as appropriate).

In addition to the costs noted above, the following environmental benefits are also described for each alternative and the proposed action:

- The average annual production of commercial products.
- The expected increase of tax payments to state and local jurisdictions during construction, operation, and decommissioning.
- Creation and improvement of transportation infrastructure and other facilities.
- Any other environmental benefits.

Both alternative sites and alternative technologies are discussed for the reasonable alternatives in this subsection.

19.5.3.1 Cost-Benefit Analysis of the Alternative Sites

This subsection discusses the costs and benefits of the proposed site in Eunice, NM, as well as the alternative sites, EnergyPlex Park Site and IIFP Site located near Hobbs, NM. For this analysis, the EIPC design (described in Section 19.2) and the construction, operation, and decommissioning impacts (described in Section 19.4) are assumed to be equivalent for each site. This assumption allows for the cost and benefits to be compared both comprehensively and consistently.

19.5.3.1.1 Proposed Site (Eunice, NM)

The environmental impacts anticipated due to construction, operation, and decommissioning of the EIPC at the Eunice, NM, site are summarized below.

19.5.3.1.1.1 Environmental Degradation

Air Quality

As summarized in Subsection 19.4.2.1.1, facility construction and decommissioning result in localized increases in air emissions. Earthmoving, excavation, clearing, pile-driving, erection, and construction-related traffic generate fugitive dust and fine PM. Vehicles and engine-driven equipment generate combustion product emissions such as CO, NO_x and to a lesser extent, SO_2.

During operation of the EIPC, several combustion sources would contribute to gaseous air emissions. In addition, standby diesel generators would be present at the facility. Each of these sources exhausts emissions to the atmosphere through an associated stack. Emissions during operation are summarized in Section 19.4.2, Tables 19.4.2-1 through Table 19.4.2-9. Standard emission control measures would be employed to limit emissions and air quality impacts during operation. Emissions generated from facility operation would be regulated by applicable air permits, ensuring compliance with NAAQS and other applicable regulatory requirements.

Air quality impacts during decommissioning are similar to the air quality impacts listed for plant construction.

Water Quality

Groundwater is not affected by construction, operation, or decommissioning activities. Groundwater is not used as a water source during operation, and excavation during both construction and decommissioning activities is above groundwater level such that no dewatering of groundwater occurs.

As noted in Subsection 19.4.4.1.1.1, no surface water features such as creeks, streams, or ponds are present on or in the immediate area surrounding the Proposed Eunice Site. Therefore, there are no direct effects to surface water resources from construction. In addition, as no surface water features are present or in the immediate vicinity of the project site and BMPs are used to minimize stormwater runoff, there are no indirect impacts to surface water hydrology from construction. Surface water impacts during decommissioning are similar to those during construction and no direct or indirect impacts on surface water are expected.

As noted in Subsection 19.4.4.1.1.2, facility operation entails withdrawal of water from the Eunice Municipal water supply system, and wastewater is discharged to the Eunice wastewater system and the evaporation pond. As a result, there are no direct impacts to surface water from facility operation. As no surface waters are utilized by the facility during operation and all stormwater runoff is managed through the use of design controls and a stormwater retention pond, there are no indirect impacts to surface water hydrology during operation.

Biotic Resources

As noted in Subsection 19.4.1.1.1, facility construction converts 55.7 ac. (22.5 ha) of scrub/shrub habitat to industrial facilities. An additional 37.5 ac. (15.2 ha) of habitat are temporarily impacted for construction laydown and parking. Subsection 19.4.5.1 summarizes impacts to biotic resources during construction. Wildlife potentially affected by construction activities includes bird, mammal, and/or herpetofauna species that occasionally use the site as a travel corridor or for foraging and resting. Wildlife occurrence and use on the Proposed Eunice Site are limited due to past grazing disturbance, lack of diverse habitat types, and lack of surface water. The loss of scrub/shrub habitat to industrial facilities is minor when compared with the 46,225 ac. (18,706 ha) of scrub/shrub habitat remaining within a 5-mi. (8-km) radius of the site.

As described in Subsection 19.3.5.7.2.2, the project site is located in the Central Flyway corridor, centered approximately 300 mi. (483 km) east of the project site. Waterfowl and shorebirds may utilize playa lakes and human-made ponds near the project site but are not expected to stop over in the project site due to the lack of surface water features. To minimize the impact to migratory bird species, ground disturbance and vegetation removal are conducted

outside of the primary breeding season for migratory songbirds, when feasible. If construction must occur during the breeding season, the area will be surveyed for active nest sites and avoidance buffers will be established, as needed.

Subsection 19.4.5.2 summarizes the impacts to biotic resources during operation. Wildlife use and occurrence on the Proposed Eunice Site are expected to be low due to the history of disturbance and lack of surface water features. Unused open areas on-site are left undisturbed during operation for the benefit of wildlife. Birds crossing through the project site may collide with tall buildings and transmission lines. Due to the lack of tall structures, the EIPC is not expected to result in significant mortality from bird collisions, although infrequent bird collisions resulting in mortality may occur. Eden is considering down-shielding of lighting, which mitigates impacts on birds and other species affected by artificial lighting.

Following cessation of EIPC operation, the facility is to be decommissioned. Decommissioning activities, however, are similar to construction activities, and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, impacts from decommissioning are anticipated to be similar to impacts associated with construction activities.

Aesthetic Resources

The impacts of the EIPC at the Proposed Eunice Site location on aesthetic resources are addressed in Subsection 19.4.1.2.

Impacts to visual and scenic resources from construction are associated with machinery used to excavate and construct the facility. Vehicle traffic and fugitive dust occur during the construction phase. The constructed facilities and buildings may impact visual and scenic resources during the operation phase. Impacts to visual and scenic resources from the decommissioning phase include similar activities and equipment used during the construction phase.

The existing site is composed entirely of undeveloped land used historically for cattle grazing and has no existing architectural features, established structures, or natural or built barriers, screens, or buffers. As such, the EIPC facilities alter the on-site condition and partially obstruct views of the existing landscape. However, the visual setting of the site is generally flat and uniform in landform, has a low vegetation diversity, and has a low scenic quality and sensitivity rating (see Subsection 19.3.1.2.4).

As described in Subsection 19.3.1.2.1, the proposed EIPC site is located on relatively flat terrain and the structures are observable from nearby roadways and properties. Visibility for a majority of the EIPC facilities occurs by individuals to the northeast and east, where other industrial facilities are located, and by motorists traveling west to east along NM-176. It is unlikely that the proposed facility would be visible from the city of Eunice, NM, which is the closest population center. The few dispersed residences along NM-176 and NM-18 may experience temporary visual impacts of fugitive dust from the project site and from equipment during transit to the project site.

As described in Section 19.3.1.2.1, the viewshed to the east consists of pastureland and the Lea County Landfill and to the northeast the URENCO facility. To the south and west, the viewshed is primarily pastureland. Because the viewshed to the northeast and east includes major industrial and commercial facilities, addition of the EIPC does not significantly alter the visual setting.

At the end of the license term, the EIPC is to be decommissioned for unrestricted use and termination of the license. Decommissioning activities are similar to those of the construction phase with minimal impact on aesthetic resources.

Socioeconomics

As noted in Subsection 19.4.7.1, construction, operation, and decommissioning of the EIPC at the Proposed Eunice Site would result in a minor influx of workers to the area. This results in increased demand for housing, public services, and public education, while also increased traffic on the local highway near the site. Based on the evaluation provided in Subsection 19.4.7.1, the region surrounding the proposed Eunice site has sufficient housing and public services to support the EIPC without a noticeable change in housing, public services, and public education demand. In addition, increases in traffic during construction, operation, and decommissioning are minimal compared with existing traffic flow and notable increases in traffic are limited to NM-176 near the EIPC driveway, as noted in Subsection 19.4.7.2.

Noise

The impact of facility construction on noise emissions is discussed in Subsection 19.4.2.2.1. The operation of heavy equipment would be the primary source of noise during construction of the EIPC. This noise would be perceptible in the immediate construction area. However, the closest noise receptors are located approximately 1.7 mi. (2.7 km) from the Proposed Eunice Site centerpoint. At this distance, construction noise attenuates to levels of approximately 42 dBA or less, below Lea County's nighttime limit and the USEPA's recommended limit of 55 dBA. On-site noise level exposure can also be controlled through BMPs, such as appropriate training, PPE, and periodic health and safety monitoring. The impact of noise during decommissioning is similar to noise impacts during construction, as both phases involve operation of heavy equipment.

The impact of facility operation on noise emissions is discussed in Subsection 19.4.2.2.2. External noise emissions from the EIPC during operation are primarily limited by the walls of the facility and other physical barriers. The only outdoor equipment that produces considerable sound levels are the MDCTs. The loudest component of the MDCT noise is the fan discharge, which has a noise level of 74 dBA at 50 ft. (15 m). This noise level attenuates to below 50 dBA, Lea County, nighttime noise limit, at the property border and below 30 dBA at the nearest residence, which is inaudible over typical background noise levels.

Land Use

As noted in Subsection 19.4.1.1.1, EIPC construction would result in the permanent conversion of approximately 55.7 ac. (22.5 ha) of developed low- to medium-intensity land use and scrub/shrub use to industrial facility use. Direct construction impacts also include temporary impact of 37.5 ac. (15.2 ha) of scrub/shrub land used for scrub/shrub land used for the construction parking area, construction materials staging and laydown area, and utilities installation. In addition to the EIPC facility, the off-site utility corridor (33.2 ac. [13.4 ha]) comprises scrub/shrub and developed land that is temporarily impacted for utility installation. These temporary impact areas are restored using native herbaceous species. The loss of scrub/shrub is minor when compared with the 45,225 ac. (18,706 ha) of scrub/shrub remaining within the 5-mi. (8-km) radius of the site.

As noted in Subsection 19.4.1.1.2, there are no federal special land use classification areas within the region or in the vicinity of the Proposed Eunice Site. Operation of the facility would not result in any direct or indirect impacts to special land use classification areas.

The EIPC location at the Proposed Eunice Site results in some loss of prime farmland of statewide importance. As noted in Subsection 19.4.1.1.3, prime farmland of statewide importance makes up 98 percent of the 55.7 ac. (22.5 ha) of permanent construction conversion and 100 percent of the 37.5 ac. (15.2 ha) of temporary construction conversion. However, prime farmland of statewide importance occurs in approximately 23 percent of the area in the region or 11,678 ac. (4726 ha).

Impacts of decommissioning on land uses are described in Subsection 19.4.1.1.7. Following the cessation of operation, the facility is to be decommissioned. Decommissioning activities are similar to construction activities and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. Resultant land uses following decommissioning are undetermined, but may consist of industrial reuse, pastureland, or open space. As such, direct and indirect impacts from decommissioning are anticipated to be similar to the impacts associated with construction.

19.5.3.1.1.2 Effects on Public Health and Safety

The effects on public health and safety for the EIPC are described in Section 19.4.8.

Potential hazards to workforce during construction and decommissioning would be typical to those on any comparable construction site, including slips, trips, falls, heavy lifting, noise, sharp objects, and movement of heavy equipment. Impacts to the public would include fugitive dust, traffic, and air emissions. These impacts are expected to be temporary and localized at or near the site.

Chemicals used within the facility during operation are contained, limiting the workforce and public exposure. Minor impacts to the public would be experienced due to increased vehicle emissions from commuting employees and truck deliveries, as well as air emissions from stationary equipment and minor doses of radiation from the transport of radioactive materials. Radioactive gaseous emissions released from the facility would be below regulatory limits.

19.5.3.1.1.3 Other Costs

No other environmental costs, such as unrealized tax revenues or diminished recreational values, have been identified. No transportation impacts, except for the minor traffic impacts on local roads discussed above in Subsection 19.5.3.1.1.1, are anticipated.

19.5.3.1.1.4 Environmental Benefits

As noted in Subsection 19.4.7.1.1, EIPC construction is projected to generate about 26 – 233 construction jobs during construction activities, depending on the construction phase. Facility operation is projected to generate about 119 – 146 permanent operational jobs. The expected workforce during decommissioning is expected to generate up to 71 jobs. Additionally, economic activity would be stimulated via the wages earned and spending by facility employees.

In addition to economic benefits, the project is beneficial to the health of the population throughout the country who are in need of diagnostic tests that require Tc-99m and other isotopes. The facility is expected to be capable of satisfying over 100 percent of the annual demand for Tc-99m in the United States and to offer a more reliable supply of this isotope than presently exists. This characterizes a significant health benefit. The facility also generates I-131, Lu-177, and Xe-133, which creates additional health benefits.

19.5.3.1.1.5 Production of Commercial Products

The capacity of the EIPC allows for an average production of about 234,000 six-day Ci (8700 TBq) of Mo-99 per year, translating to millions of doses of Tc-99m per year for diagnostic tests. In addition, the facility is projected to produce an average of approximately 200,000 Ci (7400 TBq) of I-131 and 200,000 Ci (7400 TBq) of Xe-133 per year and 60,000 Ci (2220 TBq) of Lu-177.

19.5.3.1.1.6 Increase in Tax Payments

A summary of tax revenues for the EIPC is provided in Subsection 19.4.7.1.5. During construction, Eden estimates an annual tax revenue of $472,500 in state income tax and gross receipts tax, and $675,000 in federal income tax revenue. During operation, Eden estimates $1.2 million in state personnel income tax and New Mexico gross receipts tax and approximately $1.8 million in federal tax revenue. Property tax paid for the undeveloped EIPC in 2021 was $5485 and remained the same in 2022. Future property taxes on the EIPC are determined based on the assessed value of the property. At this time, that value cannot be determined, but is anticipated to be greater as the land is currently undeveloped. In addition to income and property tax revenues, revenues for sales tax increase through worker expenditures and facility spending on materials and supplies.

The composition of the workforce needed for decommissioning the EIPC is similar, but as noted in Subsection 19.4.7.1.1, smaller than the workforce needed during the construction phase. Therefore, decommissioning has similar but smaller impacts than those for the construction phase.

19.5.3.1.1.7 Creation and Improvement of Transportation Infrastructure and Other Facilities

No creation or improvement of infrastructure is anticipated to occur directly due to the project. However, improvements such as widening or adding turning lanes to existing roads neighboring the proposed site may be required in order to alleviate traffic congestion during construction.

19.5.3.1.1.8 Other Benefits

No other significant benefits have been identified.

19.5.3.1.2 EnergyPlex Park Site and IIFP Site, Hobbs, NM

19.5.3.1.2.1 Environmental Degradation

The environmental costs that would be anticipated due to construction, operation, and decommissioning of the EIPC at either the EnergyPlex Park Site or the IIFP Site located near Hobbs, NM, are summarized below.

Air Quality

Air emissions at alternative sites would be the same as those identified for the Proposed Eunice Site in Subsection 19.5.3.1.1.1 for construction, operation, and decommissioning. As both alternative sites are located Lea County, the ambient air quality is currently in attainment with the NAAQS. Emissions generated from facility operation would be regulated by applicable air quality permits, ensuring compliance with NAAQS and other applicable regulatory documents.

Water Quality

Water quality impacts at the alternative sites are provided in Subsection 19.5.2.1.2.5. As the EIPC water supply is to be provided from the city municipal water supply and wastewater is to be discharged to the municipal wastewater treatment plant and on-site evaporation pond, there are no direct impacts to surface water quality at the alternative site locations. During construction and decommissioning, BMPs as part of a stormwater pollution prevention plan would be implemented to mitigate indirect impacts of water resources. During operation, design controls, along with a stormwater retention pond, would mitigate stormwater runoff to nearby surface water features. In addition, the High Plains aquifer below both alternative sites is located well below the excavation depth of EIPC. As a result, no dewatering of the High Plains aquifer is expected.

Biotic Resources

Potential impacts to ecological resources associated with the construction and operation of the EIPC at the EnergyPlex Park Site or at the IIFP Site are provided in Subsection 19.5.2.1.2.6. Construction of the facility would cause limited disturbance to on-site undeveloped rangelands and minor displacement of the migrating birds utilizing the agricultural lands to feed. Some displacement of fauna, particularly birds and mammals, would result from construction activities, noise, and lighting. The land disturbance for the EIPC at either of the alternative sites would be similar to the land disturbance at the Proposed Eunice Site provided in Subsection 19.5.3.1.1.1. While species of concern may be present at either of the alternative sites, no unique or native habitat suitable for threatened or endangered plant or animal species have been identified within the site boundary.

Similar to the Proposed Eunice Site summarized in Subsection 19.5.3.1.1.1, migratory birds, including waterfowl and shorebirds, may utilize playa lakes and human-made ponds near the project site. To minimize the impact to migratory bird species, ground disturbance and vegetation removal would be conducted outside of the primary breeding season for migratory songbirds, when feasible. If construction must occur during the breeding season, the area will be surveyed for active nest sites and avoidance buffers will be established as necessary. During operation, birds crossing through the project site may collide with tall buildings and transmission lines. Due to the lack of tall structures, the EIPC is not expected to result in significant mortality from bird collisions, although infrequent bird collisions resulting in mortality may occur.

Following cessation of EIPC operation, the facility is to be decommissioned. Decommissioning activities, however, are similar to construction activities, and involve heavy equipment to dismantle buildings and remove roadway and parking facilities. As such, impacts from decommissioning are anticipated to be similar to impacts associated with construction activities.

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Aesthetic Resources

The EIPC impact on visual resources for the alternative sites is addressed in Subsection 19.5.2.1.2.2.2. The existing land use within the EnergyPlex Site boundary currently consists of agricultural and grazing with no existing architectural features, established structures, or natural barriers, screens, or buffers. Similarly, the existing land use for the IIFP Site consists of undeveloped vacant land and limited grazing. The visual settings for both alternative sites are generally flat and uniform in landform with low vegetation diversity; consequently, construction of the EIPC at the alternative sites alters site conditions and partially obstructs views of the existing landscape during construction, operation, and decommissioning phases.

The severity of visual impacts on the human population would largely be determined by the project facilities' visibility from sensitive viewing areas. Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of both the EnergyPlex Park Site and IIFP Site are undeveloped, are used for mineral extraction, or are industrial land use, and there are no sensitive viewing areas or receptors within 1 mi. (1.6 km) of the site.

Socioeconomics

As noted in Subsection 19.5.2.1.2.8, construction, operation, and decommissioning of the EIPC at either of the alternative sites would result in a minor influx of workers to the area. This results in increased demand for housing, public services, and public education, while also increased traffic on the local highway near the site. Based on the evaluation, the region surrounding the alternative sites has sufficient housing, public services, and public education resources to support the EIPC without a noticeable change in housing, public services, or public education demand. Increases in traffic during construction would result in a noticeable change in traffic along NM-483. During operation and decommissioning, the expected traffic increases along NM-483 would be minor.

Noise

The impact of facility construction on noise emissions at the alternative sites is discussed in Subsection 19.5.2.1.2.3.2. The operation of heavy equipment would be the primary source of noise during construction of the EIPC. This noise would be perceptible in the immediate construction area. However, the nearest residence is located more than 2 mi. (3.2 km) from the EnergyPlex Park Site and more than 1 mi. (1.6 km) from the IIFP Site. At these distances, construction noise attenuates to levels below Lea County's nighttime limit and the USEPA's recommended limit of 55 dBA. On-site noise level exposure can also be controlled through BMPs, such as appropriate training, PPE, and periodic health and safety monitoring. The impact of noise during decommissioning is similar to noise impact during construction, as both phases involve operation of heavy equipment.

The impacts of facility operation on noise emissions at the alternative sites are discussed in Subsection 19.5.2.1.2.3.2. External noise emissions from the EIPC during operation are primarily limited by the walls of the facility and other physical barriers. The only outdoor equipment that produces considerable sound levels is the MDCTs. The loudest component of the MDCT noise is the fan discharge, which has a noise level of 74 dBA at 50 ft. (15 m). This noise level attenuates to below the 55 dBA Lea County nighttime noise limit, at the property border, and below 30 dBA at the nearest residence, which is which is typical background noise level for rural area (USEPA, 1974).

Land Use

As noted in Subsection 19.4.1.1.1, EIPC construction would result in the permanent conversion of about 55.7 ac. (22.5 ha) of rangelands to industrial land use, as well as the temporary conversion of about 37.5 ac. (15.2 ha) of rangelands to industrial land use.

A description of the existing land use impacts at the alternative site locations is provided in Subsection 19.5.2.1.2.2.1. The existing land use within the EnergyPlex Park Site boundary is agricultural. Vegetation in the area is generally dominated by Plains Sand Scrub vegetation, characterized by the presence of forbs, shrubs, and grasses that are adapted to the deep sand environment in parts of southeastern New Mexico. The existing land use within the IIFP Site consists of vacant developed land or land used for grazing.

Operation of the facility would not generate additional impacts to on-site land use. During construction and operation, no off-site land use impacts are anticipated, except for temporary disturbances to connect to municipal water supply piping. The construction at either of the alternative sites would be consistent with the current zoning of the site and the intended land use in the area.

19.5.3.1.2.2 Effects on Public Health and Safety

The effects on public health and safety for the alternative sites would be similar to the effects provided for the Proposed Eunice Site listed in Subsection 19.5.3.1.1.2. The only difference with the alternative sites would be the distance to the property boundary fenceline when evaluating public health impacts. The EnergyPlex Park property parcel is more than 800 ac. (324 ha), as noted in Subsection 19.5.2.1.2.1. This is greater than the Proposed Eunice Site property parcel of 240 ac. (97 ha). Thus, the distance to the property boundary fenceline would be expected to be greater than for the Proposed Eunice Site. As a result, the public health impacts at the property boundary would be less than those described for the Proposed Eunice Site. The IIFP parcel is approximately 200 ac. (81 ha), which is similar to that of the Proposed Eunice Site. As a result, the public health impacts at the property boundary for the IIFP Site would be similar to the health impacts identified for the Proposed Eunice Site. Worker health impacts would be the same regardless of site location. As a result, the worker health impacts identified in Subsection 19.5.3.1.1.2 would be the same at the alternative site locations.

19.5.3.1.2.3 Other Costs

No further environmental costs, such as unrealized tax revenues or diminished recreational values, have been identified. No transportation impacts, except for the traffic impacts on local roads discussed above in this subsection, are anticipated.

19.5.3.1.2.4 Environmental Benefits

The environmental benefits, in terms of jobs created, as well as the additional health benefits for producing the radioisotopes, are the same as the Proposed Eunice Site location. Refer to Subsection 19.5.3.1.1.4 for additional information.

19.5.3.1.2.5 Production of Commercial Products

The production of commercial products would not be impacted by alternative site locations. Refer to Subsection 19.5.3.1.1.5 for additional information.

19.5.3.1.2.6 Increase in Tax Payments

As both alternative sites are located in Lea County, NM, tax revenues for the alternative sites would be same as those identified in Subsection 19.5.3.1.1.6 for the Proposed Eunice Site.

19.5.3.1.2.7 Creation and Improvement of Transportation Infrastructure and Other Facilities

No creation or improvement of infrastructure is anticipated to occur directly due to the project. However, improvements such as widening or adding turning lanes to existing roads neighboring the alternative project sites may be required in order to alleviate traffic congestion during construction.

19.5.3.1.2.8 Other Benefits

No other significant benefits have been identified.

19.5.3.2 Cost-Benefit Analysis of the Alternative Technologies

This subsection presents the costs and benefits of the proposed Eden technology versus alternative technologies. For this evaluation, it is assumed that the alternative technologies would be constructed at the Proposed Eunice Site in Eunice, NM. This assumption allows for the costs and benefits to be compared both comprehensively and consistently.

19.5.3.2.1 Eden (Proposed) Technology

The cost-benefit evaluation of the Eden (proposed) technology is the same as the cost-benefit evaluation provided in Subsection 19.5.3.1.1 for the proposed site location.

19.5.3.2.2 Accelerator-Driven Subcritical Operating Assembly (SHINE Medical Technologies)

19.5.3.2.2.1 Environmental Degradation

The environmental costs that would be anticipated due to construction, operation, and decommissioning of the SHINE technology are summarized below.

Air Quality

Similar to the EIPC, facility construction and decommissioning would result in localized increases in air emissions. Earthmoving, excavation, clearing, pile-driving, erection, and construction-related traffic generate fugitive dust and fine particulate matter. Vehicles and engine-driven equipment generate combustion product emissions, such as CO, NO_x, and, to a lesser extent, SO_2.

Minor emissions of NO_X, PM, and SO_2 result from facility operation. These emissions occur mainly due to natural gas heating of the facility buildings and periodic testing of the standby diesel generator, in addition to small amounts of NO_X from the SHINE process.

Water Quality

Similar to the EIPC, facility construction and decommissioning may result in some discharge of suspended solids to local drainage ditch systems. Stormwater runoff during construction would

be controlled using sediment and erosion control BMPs. There would be small probability of stormwater and sediment adversely affecting identified water resources, attributable to small surface runoff potential, as well as distance from the nearest surface water body.

Groundwater would not be affected by construction and decommissioning activities. Dewatering of groundwater is not expected.

There is increased potential for oil or chemical discharges to surface water and groundwater resulting from accidental spills during construction, decommissioning, and operation. A small probability of release is expected due to oil and chemical control measures.

Operation of the facility requires water for use during the SHINE processes for: target solution and makeup water, isotope processing, potable water, fire protection, and facility heating and cooling systems. All required water would be withdrawn from municipal water supplies.

Operation of the facility would also require the discharge of wastewater including sanitary wastes, blowdown resulting from building heating boilers, and liquid wastes from SHINE and isotope processing. All wastewater would be discharged to city sanitary waste system and would be in compliance with federal, state, and local pretreatment and wastewater discharge requirements.

Developing the facility site would generate small pollutant loads and increased runoff from roadways, parking areas, industrial activities, and landscaping.

Biotic Resources

As the size of the SHINE facility is similar to the size of the EIPC, the impact on biotic resources is expected to be similar to the EIPC as outlined in Subsection 19.5.3.1.1.1. Facility construction would generate limited disturbance to on-site undeveloped rangelands, as well as minor displacement of migrating birds that use the rangelands to feed. Construction activities, noise, and lighting result in negligible displacement of fauna, predominantly birds and mammals. During construction, potential for birds to collide with human-made structures, such as cranes and buildings, is small. Operation of the facility does not generate additional impacts except a small potential for bird collisions with buildings and a small disturbance to wildlife due to security lighting at night.

Environmental costs associated with decommissioning on biotic resources are bounded by plant construction.

Aesthetic Resources

As the size of the SHINE facility is smaller than the size of the proposed EIPC, the environmental impacts on aesthetic resources for the SHINE facility would be similar to or less than those of the EIPC described in Subsection 19.5.3.1.1.1.

Industrial structures and construction equipment could affect visual resources in the vicinity of the Proposed Eunice Site. During facility construction, temporary localized visual impacts would likely occur as a result of ongoing ingress, exiting, and the presence of heavy equipment and construction materials being staged on-site within laydown areas, as well as the regular presence of large transport vehicles, construction equipment, and trailers.

Existing land use within the Proposed Eunice Site boundary consists of undeveloped rangelands and land used for grazing, with no existing architectural features, established structures, or natural or built barriers, screens, or buffers. The visual setting of the Proposed Eunice Site is generally flat and uniform in landform with low vegetation diversity and has a low visual quality rating. Consequently, construction of the SHINE facility would alter site conditions and partially obstruct views of existing landscape.

The severity of visual impacts on the human population would largely be determined by the project facilities' visibility from sensitive viewing areas. Based on examination of aerial imagery, all areas within 1 mi. of the Proposed Eunice Site are undeveloped, used for mineral extraction, or industrial land use, and there are no sensitive viewing areas or receptors within 1 mi. of the site.

Environmental costs associated with aesthetic resources during decommissioning would be similar to and bounded by plant construction.

Socioeconomics

Similar to the EIPC socioeconomic impacts identified in Subsection 19.5.3.1.1.1, construction, operation, and decommissioning of the SHINE facility at the Proposed Eunice Site would result in a minor influx of workers to the area. This results in increased demand for housing, public services, and public education, while also increasing traffic on the local highway near the site. Based on the existing conditions in the region identified in Subsection 19.4.7.1, the region surrounding the Proposed Eunice Site has sufficient housing public services to support the SHINE facility without a noticeable change in housing, public services, or public education demand. In addition, increases in traffic during the construction, operation, and decommissioning phases, is minimal compared with existing traffic flow and notable increases in traffic are limited to NM-176 near the EIPC driveway, as noted in Subsection 19.4.7.2.

Facility operation would result in slight increases in local traffic due to vehicle movements associated with employees and deliveries and shipments of supplies and products.

Facility construction would result in some temporary rises in demand for housing, public education resources, police, fire, medical and social services, parks and recreation facilities, and water supply and wastewater treatment facilities provided for construction workers who move into the area.

Facility operation would result in a small rise in demand for housing, public education resources, police, fire, medical and social services, parks and recreation facilities, and water supply and treatment facilities provided for operations workers who move into the area.

During decommissioning, the peak workforce is 261 (per NUREG-2183), similar to the peak workforce for the EIPC during construction. As a result, the socioeconomic costs during decommissioning would be similar to EIPC plant construction identified in Subsection 19.5.3.1.1.1.

Noise

Facility construction would result in some temporary increases in noise, resulting from the utilization of heavy equipment on the site, as well as construction workforce traffic in early morning and late afternoon.

Facility operation would result in slight increases in noise primarily from vehicle movements from employees, as well as deliveries and shipments of supplies and products. External noise emissions from the SHINE facility during operation is primarily limited by the walls and other physical barriers of the facility itself.

Land Use

Facility construction would result in the permanent conversion of approximately 26 ac. (10.5 ha) of rangelands to industrial land use, and the temporary conversion of 14 ac. (5.7 ha) to support construction. The land permanently or temporarily converted to industrial land use is undeveloped rangeland. Facility operation would not result in additional impacts to on-site land use. Off-site land use would be similar to the EIPC off-site land use, including a utility corridor along NM-176 for city water supply and wastewater discharge lines.

19.5.3.2.2.2 Effects on Public Health and Safety

During construction and decommissioning, effects on public health and safety are similar to EIPC facility, as identified in Subsection 19.5.3.1.1.2, as these effects would be typical for large construction projects of industrial facilities.

During facility operation, slight impacts to public health and safety may occur due to vehicle traffic, air pollution emissions (vehicle exhaust and emissions of conventional pollutants from stationary equipment), sanitary wastes, and conventional solid wastes. Additionally, the public would be exposed to small doses of radiation resulting from transportation of radioactive materials to and from the site, as well as direct radiation and releases of gaseous effluents from the SHINE process. All radioactive materials would be strictly controlled, and all radiological doses would remain in compliance with regulatory limits.

19.5.3.2.2.3 Other Costs

No further environmental costs, such as unrealized tax revenues or diminished recreational values, have been identified. No transportation impacts, except for the traffic impacts on local roads discussed above in this subsection, are anticipated.

19.5.3.2.2.4 Environmental Benefits

Construction of the facility is projected to generate approximately 420 construction jobs during the peak of construction activities. Operation of the facility is projected to generate approximately 150 permanent operational jobs. Additionally, economic activity would be stimulated via the wages earned and money spent by facility employees.

In addition to economic benefits, the project would also be beneficial to the health of the population throughout the country who are in need of diagnostic tests that require Tc-99m and other isotopes. The facility is expected to be capable of satisfying approximately half of the annual demand for Tc-99m in the United States and to offer a more reliable supply of this isotope than currently exists. This characterizes a significant health benefit. The facility would also generate I-131 and Xe-133, which creates additional health benefits.

19.5.3.2.2.5 Commercial Product Production

The capacity of the facility would allow for an average production of 156,000 six-day Ci (5772 six-day TBq) of Mo-99 per year, translating to millions of doses of Tc-99m per year for diagnostic tests. Additionally, the facility is anticipated to produce an average of approximately 100,000 Ci (3700 TBq) of I-131 and 100,000 Ci (3700 TBq) of Xe-133 per year.

19.5.3.2.2.6 Increase of State and Local Tax Revenue

The impact of state and local taxes for the SHINE facility would be similar to that identified for the EIPC facility in Subsection 19.5.3.1.1.6.

19.5.3.2.2.7 Creation and Improvement of Transportation Infrastructure and Other Facilities

No creation or improvement of infrastructure is anticipated to occur directly due to the project. However, improvements such as widening or adding turning lanes to existing roads neighboring the project site would be required in order to alleviate traffic congestion.

19.5.3.2.2.8 Other Benefits

No other significant benefits have been identified.

19.5.3.2.3 Irradiation of Mo-100 Target in a Linear Accelerator (NorthStar)

19.5.3.2.3.1 Environmental Degradation

The expected environmental impacts from construction and operation of the neutron activation of Mo-98, linear accelerator (NorthStar) technology are summarized below.

Air Quality

Similar to the EIPC, facility construction and decommissioning would result in localized increases in air emissions. Earthmoving, excavation, clearing, pile-driving, erection, and construction-related traffic generate fugitive dust and fine particulate matter. Vehicles and engine-driven equipment generate combustion product emissions, such as CO, NO_x, and, to a lesser extent, SO_2.

Air emissions during operation are discussed in Subsection 19.5.2.2.2.2.3. Air emissions during operation would be expected from the building's heating system and emergency generators. Process emissions would not be anticipated, but the chemicals used to dissolve Mo-99 targets and the resulting evaporation may produce small emissions. Operating air emissions include NO_x, volatile organic compounds, CO, SO_2, particulate matter with an aerodynamic diameter less than 10 μm (PM_{10}), , particulate matter with an aerodynamic diameter less than 2.5 μm ($PM_{2.5}$), and CO_2. Additionally, the facility's operation would generate an increase in vehicular emissions as a result of shipping radioisotopes and commuting workers.

Water Quality

Impacts of the NorthStar facility on water quality are addressed in Subsection 19.5.2.2.2.2.5. Similar to the EIPC, stormwater runoff during construction would be controlled using sediment and erosion control BMPs. There is a small probability of stormwater and sediment adversely

affecting identified water resources due to small surface runoff potential, as well as distance from the nearest surface water body.

The depth of excavation for the NorthStar facility is up to 30 ft. (9 m). This is well above the groundwater depth of 100 ft. (30.5 m) for the area.

All water required for the facility is taken from the municipal water supply. No industrial wastewater discharges are expected from facility operation. The NorthStar facility would have normal sanitary sewer discharges. As such, there is no direct impact from operation on surface water resources. Indirect impacts on surface water from stormwater runoff during operation would be controlled similar to the EIPC, with an engineered drain system and a stormwater retention pond.

Biotic Resources

As the size of the NorthStar facility is smaller than the EIPC, environmental costs associated with biotic resources are expected to be similar, but less than that of the EIPC. construction and decommissioning of the facility would cause limited disturbance to on-site undeveloped rangelands and minor displacement of migrating birds that utilize the rangelands to feed. Negligible displacement of fauna, particularly birds and mammals, would result from construction activities, noise, and lighting. There would be a minor potential for birds to collide with human-made structures, such as cranes and buildings, during construction. Facility operation would not result in additional impacts except a small potential for birds to collide with buildings and a slight disturbance to wildlife due to security lighting at night.

Aesthetic Resources

As the size of the NorthStar facility is smaller than the size of the EIPC, the impact on aesthetic resources is expected to be similar to the impact of the EIPC.

Visual resources in the vicinity of the Proposed Eunice Site could be affected by industrial structures and construction equipment. During facility construction and decommissioning, temporary localized visual impacts would likely occur as a result of ongoing ingress, exiting, and the presence of heavy equipment and construction materials being staged on-site within laydown areas, as well as the regular presence of large transport vehicles, construction equipment, and trailers.

Existing land use within the Proposed Eunice Site boundary consists of undeveloped rangelands and land used for grazing with no existing architectural features, established structures, or natural or built barriers, screens, or buffers. The visual setting of the Proposed Eunice Site is generally flat and uniform in landform with low vegetation diversity and a low visual quality rating. Consequently, construction of the NorthStar facility would alter site conditions and partially obstruct views of existing landscape.

The severity of visual impacts on the human population would largely be determined by the project facilities' visibility from sensitive viewing areas. Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the Proposed Eunice Site are undeveloped, used for mineral extraction, or industrial land use, and there are no sensitive viewing areas or receptors within 1 mi. (1.6 km) of the site.

Socioeconomics

Similar to the EIPC, socioeconomic impacts identified in Subsection 19.5.3.1.1.1 during construction, operation, and decommissioning of the NorthStar facility at the Proposed Eunice Site would result in a minor influx of workers to the area. This results in increased demand for housing, public services, and public education, while also increasing traffic on the local highway near the site. Based on the existing conditions in the region identified in Subsection 19.4.7.1, the region surrounding the Proposed Eunice Site has sufficient housing public services to support the NorthStar facility without a noticeable change in housing, public services, or public education demand. In addition, increases in traffic during the construction, operation, and decommissioning phases are minimal compared to existing traffic flow and notable increases in traffic are limited to NM-176 near the EIPC driveway as noted in Subsection 19.4.7.2.

Noise

Facility construction would result in some temporary increases in noise from the utilization of heavy equipment on the site, as well as construction workforce traffic in early morning and late afternoon.

Facility operation would result in small increases in noise largely from vehicle movements associated with employees and deliveries and shipments of supplies and products. Normal operation would involve noise from outdoor air-cooled heat exchangers, which provide the necessary process cooling. Based on the NorthStar Environmental Assessment, the noise from the fans does not exceed 60 dBA at a distance of 30 ft. (9 m) (DOE, 2012). This is lower than the estimated fan noise from the EIPC MDCTs.

Land Use

Construction of the facility would result in the permanent conversion of about 30 ac. (12.1 ha) of rangelands to industrial land use. Temporary conversions of land to support construction activities would be projected to be similar to the SHINE facility, which means that about 14 ac. (5.7 ha) of rangelands would be temporarily converted to industrial land use.

The land permanently or temporarily converted to industrial land use is considered undeveloped rangeland.

Operation of the facility would not result in additional impacts to on-site land use.

No impacts to off-site land use are anticipated during construction, operation, or decommissioning, with the exception of a utility corridor to provide city water to the site and a wastewater discharge pipe to connect to the Eunice sewer pipeline.

19.5.3.2.3.2 Effects on Public Health and Safety

During construction, small impacts to public health and safety may occur due to vehicle traffic, air pollution emissions (vehicle exhaust and fugitive dust), sanitary wastes, and conventional solid wastes. Any such impacts would be temporary and remain restricted to the immediate project site vicinity.

During facility operation, slight impacts to public health and safety may occur due to vehicle traffic, air pollution emissions (vehicle exhaust and emissions of conventional pollutants from

stationary equipment), sanitary wastes, and conventional solid wastes. Additionally, the public would be exposed to small doses of radiation resulting from transportation of radioactive materials to and from the site, as well as direct radiation and releases of gaseous effluents from the process. All radioactive materials would be strictly controlled, and all radiological doses would remain in compliance with regulatory limits.

19.5.3.2.3.3 Other Costs

No further environmental costs, such as unrealized tax revenues or diminished recreational values, have been identified. No transportation impacts, except for the traffic impacts on local roads discussed above in this subsection, are anticipated.

19.5.3.2.3.4 Environmental Benefits

Construction of this type of facility would be projected to generate about the same quantity of construction jobs as the SHINE facility, equating to about 420 construction jobs during the peak of construction activities. Facility operation would generate about 150 permanent operational jobs. Additionally, economic activity would be stimulated by the wages earned and money spent by facility employees.

In addition to economic benefits, the project is also beneficial to the health of the population throughout the country in need of diagnostic tests that require Tc-99m. The facility would be projected to produce the same quantity of Tc-99m as the SHINE facility, which means it would satisfy about half of the annual demand for these isotopes in the United States, representing a significant health benefit. However, this type of facility would not produce I-131 and Xe-133.

19.5.3.2.3.5 Commercial Product Production

The linear accelerator facility is designed to allow for an increase in production when required by demand. However, at full production, the facility would be projected to produce 3000 six-day Ci (111 TBq) per week, which means it is capable of producing up to about 156,000 six-day Ci (5772 TBq) of Mo-99 per year.

19.5.3.2.3.6 Increase of State and Local Tax Revenue

The facility would be projected to generate about the same amount of taxes as the EIPC, as summarized in Subsection 19.5.3.1.1.6.

19.5.3.2.3.7 Creation and Improvement of Transportation Infrastructure and Other Facilities

No creation or improvement of infrastructure is anticipated to occur directly due to the project. However, improvements such as widening or adding turning lanes to existing roads neighboring the project site would be required in order to alleviate traffic congestion.

19.5.3.2.3.8 Other Benefits

No additional benefits are offered by any of the alternative technologies.

19.5.3.2.4 Fission of Uranium Targets from Research Reactors (NWMI)

19.5.3.2.4.1 Environmental Degradation

The environmental impacts that would be expected to result from construction and operation of the NWMI technology are summarized below.

Air Quality

Construction activities would result in localized increases in air emissions. Earthmoving, excavation, clearing, pile-driving, erection, batch plant operation, and construction-related traffic generate particulate dust and fine particulate matter. Vehicles and engine-driven equipment generate combustion product emissions such as CO, NO_x, and, to a lesser extent, SO_2.

Operation activities may result in a slight increase in vehicle traffic in the immediate area of the facility, which could cause a slight increase in internal combustion emissions such as CO, NO_x, and, to a lesser extent, SO_2. Operation of the emergency standby generator would also result in a slight increase in emission products, but due to intermittent use, these emissions would be low. No pollutant is estimated to be released during normal operation that exceeds NAAQS.

Water Quality

Impacts of the NWMI facility on water quality are addressed in Subsection 19.5.2.2.2.3.5. Similar to the EIPC, stormwater runoff during construction would be controlled using sediment and erosion control BMPs. There is a small probability of stormwater and sediment adversely affecting identified water resources due to small surface runoff potential, as well as distance from the nearest surface water body.

The depth of excavation for the NWMI facility is up to 15.5 ft. (4.7 m) (NWMI, 2013). This is well above the groundwater depth of 100 ft. (30.5 m) for the area.

All water required for the facility is withdrawn from the municipal water supply. No industrial wastewater discharges are expected from facility operation. The NWMI facility would have normal sanitary sewer discharges. As such, there is no direct impact from operation on surface water resources. Indirect impacts on surface water from stormwater runoff during operation would be controlled similar to the EIPC, with an engineered drain system and a stormwater retention pond.

Biotic Resources

As the size of the NWMI facility is smaller than the EIPC, the impact on biotic resources is expected to be bounded by the EIPC. Construction and decommissioning of the facility would cause limited disturbance to on-site undeveloped rangelands and minor displacement of migrating birds that utilize the rangelands to feed. Negligible displacement of fauna, particularly birds and mammals, would result from construction activities. There would be minor potential for birds to collide with humanmade structures, such as cranes and buildings, during construction. Facility operation would not result in additional impacts, except for a small potential for birds to collide with buildings and slight disturbance to wildlife due to security lighting at night.

Aesthetic Resources

As the size of the NWMI facility is smaller than the EIPC, the impact on aesthetic resources is expected to be bounded by the EIPC. Visual resources in the vicinity of the Proposed Eunice Site could be affected by industrial structures and construction equipment. During facility construction and decommissioning, temporary localized visual impacts would likely occur as a result of ongoing ingress, exiting, and the presence of heavy equipment and construction materials being staged on-site within laydown areas, as well as the regular presence of large transport vehicles, construction equipment and trailers.

Existing land use within the Proposed Eunice Site boundary consists of undeveloped rangelands and land used for grazing, with no existing architectural features, established structures, or natural or built barriers, screens, or buffers. The visual setting of the Proposed Eunice Site is generally flat and uniform in landform with low vegetation diversity and a low visual quality rating. Consequently, construction of the EIPC alters site conditions and partially obstructs views of existing landscape.

The severity of visual impacts on the human population would largely be determined by the project facilities' visibility from sensitive viewing areas. Based on examination of aerial imagery, all areas within 1 mi. (1.6 km) of the Proposed Eunice Site are undeveloped, used for mineral extraction, or industrial land use, and there are no sensitive viewing areas or receptors within 1 mi. (1.6 km) of the site.

Socioeconomics

Similar to the EIPC socioeconomic impacts identified in Subsection 19.5.3.1.1.1, construction, operation, and decommissioning of the NWMI facility at the Proposed Eunice Site would result in a minor influx of workers to the area. This results in increased demand for housing, public services, and public education, while also increasing traffic on the local highway near the site. Based on the existing conditions in the region identified in Subsection 19.4.7.1, the region surrounding the Proposed Eunice Site has sufficient housing and public services to support the NWMI facility without a noticeable change in housing, public services, or public education demand. In addition, increases in traffic during the construction, operation, and decommissioning phases are minimal compared with existing traffic flow and notable increases in traffic are limited to NM-176 near the EIPC driveway, as noted in Subsection 19.4.7.2.

Noise

Facility construction would result in some temporary increases in noise from the utilization of heavy equipment, such as graders, bulldozers, and concrete trucks, on the site, as well as construction workforce traffic in early morning and late afternoon.

Long-term noise sources resulting from operation would include process equipment, ventilation, heating and cooling systems, and increased traffic. Process equipment would be housed inside the facility, such that the noise contribution to the environment would be minimal. The intermittent increase in traffic volume associated with normal work conditions, commercial deliveries, and the natural noise attenuation over distance would result in noise levels to receptors remaining at baseline levels.

Land Use

Impacts to land use are related to the amount of land disturbed and the type of construction on the land. The facility would be approximately 350 x 185 ft. (106.7 x 56.4 m) and would stand 65 ft. (19.8 m) tall above grade. The actual facility building would occupy a rectangular area approximately 700 x 300 ft. (213 x 91 m) at the outer perimeter and cover approximately 4.8 ac. (1.95 ha). The overall land use would be less than the proposed land use by the EIPC, which converts 55.7 ac. (22.5 ha) of rangelands to industrial facilities. Thus, the impacts to land use and visual resources are projected to be less than that for the EIPC and would be considered SMALL. There are no additional impacts to on-site land use resulting from facility operation. No impacts to off-site land use are anticipated during construction or operation.

19.5.3.2.4.2 Effects on Public Health and Safety

During construction and decommissioning, small impacts to public health and safety may occur due to vehicle traffic, air pollution emissions (vehicle exhaust and fugitive dust), sanitary wastes, and conventional solid wastes. Any such impacts would be temporary and restricted to the immediate project site vicinity. In the event of a spill or accident during construction, the impact to human health and the environment would be mitigated by following the emergency response plan.

During facility operation, small impacts to public health and safety may occur due to vehicle traffic, air pollution emissions (vehicle exhaust and emissions of conventional pollutants from stationary equipment), sanitary wastes, and conventional solid wastes, as well as accident spills and releases. Additionally, the public would be exposed to small doses of radiation resulting from transportation of radioactive materials to and from the site, as well as direct radiation and releases of gaseous effluents and liquid effluents from the process. All radioactive materials would be strictly controlled, and all radiological doses would remain in compliance with regulatory limits.

19.5.3.2.4.3 Other Costs

No further environmental costs, such as unrealized tax revenues or diminished recreational values, have been identified. No transportation impacts, except for the traffic impacts on local roads discussed above in this subsection, are anticipated.

19.5.3.2.4.4 Environmental Benefits

Construction of this type of facility would be anticipated to generate approximately the same quantity of construction jobs as the SHINE facility, which equates to about 82 construction jobs during the peak of construction activities. Facility operation would create about 98 permanent operational jobs. Additionally, economic activity would be stimulated via the wages earned, and money spent by facility employees.

In addition to economic benefits, the project is also beneficial to the health of the population throughout the country in need of diagnostic tests that require Tc-99m. The facility is projected to satisfy about half of the weekly demand for these isotopes in the United States, representing a significant health benefit.

19.5.3.2.4.5 Commercial Product Production

The facility would be projected to produce 3000 six-day Ci (111 TBq) per week, which means it is capable of producing up to approximately 156,000 six-day Ci (5772 TBq) of Mo-99 per year.

19.5.3.2.4.6 Increase of State and Local Tax Revenue

The facility would be expected to generate about the same quantity of taxes as the EIPC, as outlined in Subsection 19.5.3.1.1.6.

19.5.3.2.4.7 Creation and Improvement of Transportation Infrastructure and Other Facilities

No creation or improvement of infrastructure is anticipated to occur directly due to the project. However, improvements such as widening or adding turning lanes to existing roads neighboring the project site may be required in order to alleviate traffic congestion during construction.

19.5.3.2.4.8 Other Benefits

No additional benefits are offered by this technology alternative.

19.5.4 COMPARISON OF ENVIRONMENTAL IMPACTS

The following subsections compare the environmental impacts associated with alternative sites and alternative technologies. A comparison is provided for both construction and operation. Because environmental impacts of decommissioning are bounded by construction and operation, a separate comparison of decommissioning is not included.

19.5.4.1 Alternative Sites

This subsection compares the environmental impacts, costs, and benefits discussed in Sections 19.5.2 and 19.5.3 for the alternative sites with the impacts, costs, and benefits at the proposed Eunice site, and evaluates whether any of the alternatives would reduce or avoid adverse effects.

Table 19.5.4-1 summarizes the expected environmental impacts of project construction at the proposed Eunice site (Eunice, Lea County, NM), each of the alternative sites (EnergyPlex Park and IFPP Sites), and the No-Action Alternative. Construction impacts at the Proposed Eunice Site as well as the alternate sites are SMALL in every resource category, with the exception of transportation and cumulative effects. For transportation, the impact is considered MODERATE at the alternative sites during construction activities only. The cumulative effects are identified as SMALL to MODERATE. The environmental impact of the No-Action Alternative is SMALL for every resource category, as no construction would occur. However, the No-Action Alternative would not produce any of the benefits that would be produced by construction at the Proposed Eunice Site or the alternative sites. These benefits include the creation of jobs and increases in tax payments to the local jurisdictions in which the site is located.

Table 19.5.4-2 summarizes the expected environmental impacts of project operation at the Proposed Eunice Site, each of the alternative sites, and the No-Action Alternative. Operation impacts at the Proposed Eunice Site and both of the alternative sites are SMALL for every resource category, with the exception of cumulative effects. The cumulative effects are identified as SMALL to MODERATE. The No-Action Alternative impacts are small for every resource

category as project operation would not occur. However, the No-Action Alternative would not produce any of the benefits that would be produced by operation at the Proposed Eunice Site or alternative sites. These benefits include the creation of jobs, increases in tax payments to the local jurisdictions in which the site is located, the production of valuable commercial products, and the significant health benefits of having a reliable domestic source of diagnostic isotopes.

Based on the information summarized above, neither of the alternative sites would reduce or avoid adverse effects as compared with the Proposed Eunice Site. The No-Action Alternative would avoid the environmental impacts associated with construction and operation. However, except for cumulative effects, all impacts related to the EIPC at the Proposed Eunice Site are SMALL, and avoiding these impacts is not significant. The No-Action Alternative would not produce any of the benefits associated with the project.

19.5.4.2 Alternative Technologies

This subsection compares the environmental impacts, costs, and benefits discussed in Sections 19.5.2 and 19.5.3 above for the alternative technologies with the impacts, costs, and benefits expected for the Eden technology, and accordingly, evaluates whether any of the alternatives would reduce or avoid potential adverse effects.

Table 19.5.4-3 summarizes the expected environmental impacts for project construction of the Eden technology, each of the alternative technologies, and the No-Action Alternative. Construction impacts for the Eden technology are SMALL for every resource category, with the exception of Cumulative Impacts, which is SMALL to MODERATE. The alternative technologies likewise have SMALL expected impacts for most resource categories, with the exception of Cumulative Impacts, which is SMALL to MODERATE. The No-Action Alternative impacts are identified as SMALL for every resource category as no construction would occur. However, the No-Action Alternative would not produce any of the benefits that would be generated by the construction of the Eden technology or alternative technologies. These unrealized benefits would include the creation of jobs and increases in tax payments to the local jurisdictions in which the project is located.

Table 19.5.4-4 summarizes the expected environmental impacts for project operation of the Eden technology, each of the alternative technologies, and the No-Action Alternative. Operational impacts for the Eden technology are SMALL for every resource category, with the exception of Cumulative Effects, which are identified as SMALL to MODERATE. The alternative technologies likewise have SMALL operational impacts for every resource category, with the exception of the cumulative effects, which are identified as SMALL to MODERATE. The No-Action Alternative impacts are identified as SMALL for every resource category, as project operation would not occur. However, the No-Action Alternative would not produce any of the benefits that would be generated by the operation of the Eden technology or alternative technologies. These unrealized benefits would include the creation of jobs, increases in tax payments to the local jurisdictions in which the project is located, the production of valuable commercial products, and the significant health benefits of having a reliable domestic source of diagnostic isotopes.

Based on the information summarized above, none of the alternative technologies would reduce or avoid adverse effects as compared with the Eden project technology. The No-Action Alternative would avoid the environmental impacts associated with construction and operation. However, with the exception of transportation during construction and cumulative effects, all

impacts related to the EIPC are SMALL and avoiding these impacts is not significant. The No-Action Alternative would not produce any of the benefits associated with the project.

Table 19.5.4-1
Comparison of Construction Impacts for Proposed Eunice Site and Alternative Sites

Category	Eden Proposed Eunice Site	EnergyPlex Park Site	IIFP Site	No-Action Alternative
Land Use Impacts	SMALL	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	SMALL	SMALL	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL	SMALL
Geological, Soils, and Seismology Impacts	SMALL	SMALL	SMALL	SMALL
Water Resources Impacts	SMALL	SMALL	SMALL	SMALL
Ecology Resources Impacts				
Aquatic Resources	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources Impacts	SMALL	SMALL	SMALL	SMALL
Socioeconomics				
Housing	SMALL	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL	SMALL
Transportation	SMALL	MODERATE	MODERATE	SMALL
Human Health				
Nonradiological	SMALL	SMALL	SMALL	SMALL
Radiological	SMALL	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	MODERATE	MODERATE	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL
Cumulative Effects	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL
Environmental Benefits – Jobs	26 to 233 depending on phase	26 to 233 depending on phase	26 to 233 depending on phase	None
Environmental Benefits – Health	None	None	None	None
Production of Commercial Products	None	None	None	None
Property Tax Payments	$5485	$5485	$5485	None
Tax Revenue (Income and Corporate)	$1.1 million	$1.1 million	$1.1 million	None

Abbreviations: IIFP = International Isotopes Fluorine Products, Inc.

Table 19.5.4-2
Comparison of Operational Impacts for Proposed Eunice Site and Alternative Sites

Category	Eden Proposed Eunice Site	EnergyPlex Park Site	IIFP Site	No-Action Alternative
Land Use Impacts	SMALL	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	SMALL	SMALL	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL	SMALL
Geological, Soils, and Seismology Impacts	SMALL	SMALL	SMALL	SMALL
Water Resources Impacts	SMALL	SMALL	SMALL	SMALL
Ecology Resources Impacts				
Aquatic Resources	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources Impacts	SMALL	SMALL	SMALL	SMALL
Socioeconomics				
Housing	SMALL	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL	SMALL
Human Health				
Nonradiological	SMALL	SMALL	SMALL	SMALL
Radiological	SMALL	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL
Cumulative Effects	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL
Environmental Benefits – Jobs	119 to 146	132	132	None
Environmental Benefits – Health	Reliable source of diagnostic isotopes	Reliable source of diagnostic isotopes	Reliable source of diagnostic isotopes	None
Production of Commercial Products	Mo-99, I-131, Xe-133, Lu-177	Mo-99, I-131, Xe-133, Lu-177	Mo-99, I-131, Xe-133, Lu-177	None
Property Tax Payments	>$5485	>$5485	>$5485	None
Tax Revenue (Income and Corporate)	$3 million	$3 million	$3 million	None

Abbreviations: IIFP = International Isotopes Fluorine Products, Inc. | Mo-99 = molybdenum-99 | I-131 = iodine-131 | Xe-133 = xenon-133 | Lu-177 = lutetium-177

Table 19.5.4-3
Comparison of Construction Impacts for Eden Technology and Alternative Technologies

Category	Eden Proposed Technology	SHINE Technology	NorthStar Technology	NWMI Technology	No-Action Alternative
Land Use Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Geological, Soils, and Seismology Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Water Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Ecology Resources Impacts					
Aquatic Resources	SMALL	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Socioeconomics					
Housing	SMALL	SMALL	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL	SMALL	SMALL
Human Health					
Nonradiological	SMALL	SMALL	SMALL	SMALL	SMALL
Radiological	SMALL	SMALL	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL	SMALL
Cumulative Effects	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL
Environmental Benefits – Jobs	26 to 233 depending on phase	451 peak	5 to 50 depending on phase	82	None
Environmental Benefits – Health	None	None	None	None	None
Production of Commercial Products	None	None	None	None	None
Property Tax Payments	$5485	$5485	$5485	$5485	None
Tax Revenue (Income and Corporate)	$1.1 million	$1.1 million	<$1.1 million	$1.1 million	None

Abbreviations: NWMI = Northwest Medical Isotopes, LLC

Table 19.5.4-4
Comparison of Operational Impacts for Eden Technology and Alternative Technologies

Category	Eden Proposed Technology	SHINE Technology	NorthStar Technology	NWMI Technology	No-Action Alternative
Land Use Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Visual Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Air Quality Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Noise Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Geological, Soils, and Seismology Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Water Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Ecology Resources Impacts					
Aquatic Resources	SMALL	SMALL	SMALL	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL	SMALL	SMALL	SMALL
Historic and Cultural Resources Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Socioeconomics					
Housing	SMALL	SMALL	SMALL	SMALL	SMALL
Public Services	SMALL	SMALL	SMALL	SMALL	SMALL
Public Education	SMALL	SMALL	SMALL	SMALL	SMALL
Taxes	SMALL	SMALL	SMALL	SMALL	SMALL
Transportation	SMALL	SMALL	SMALL	SMALL	SMALL
Human Health					
Nonradiological	SMALL	SMALL	SMALL	SMALL	SMALL
Radiological	SMALL	SMALL	SMALL	SMALL	SMALL
Waste Management Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Transportation Impacts	SMALL	SMALL	SMALL	SMALL	SMALL
Postulated Accidents	SMALL	SMALL	SMALL	SMALL	SMALL
Cumulative Effects	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL - MODERATE	SMALL
Environmental Benefits – Jobs	119 to 146	150	150	98	None
Environmental Benefits – Health	Reliable source of diagnostic isotopes	Reliable source of diagnostic isotopes	Reliable source of diagnostic isotopes	Reliable source of diagnostic isotopes	None
Production of Commercial Products	Mo-99, I-131, Xe-133, Lu-177	Mo-99, I-131, Xe-133	Mo-99	Mo-99	None
Property Tax Payments	>$5485	>$5485	>$5485	>$5485	None
Tax Revenue (Income and Corporate)	$3 million	$3 million	$3 million	$3 million	None

Abbreviations: NWMI = Northwest Medical Isotopes, LLC | Mo-99 = molybdenum-99 | I-131 = iodine-131 | Xe-133 = xenon-133 | Lu-177 = lutetium-177

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Figure 19.5.2-1
Map of Alternative Sites

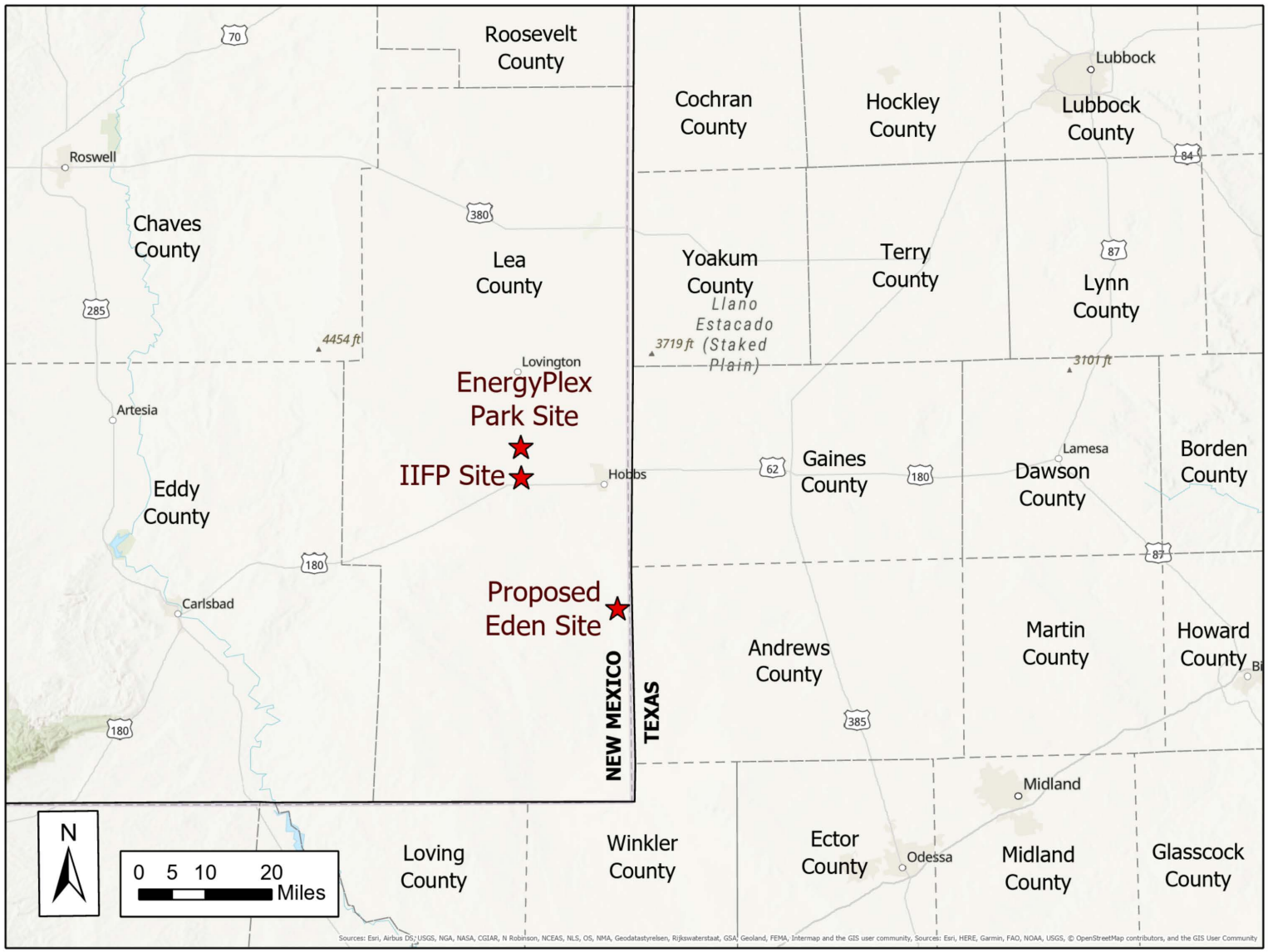

Figure 19.5.2-2
Site Map of the Proposed Eunice Site

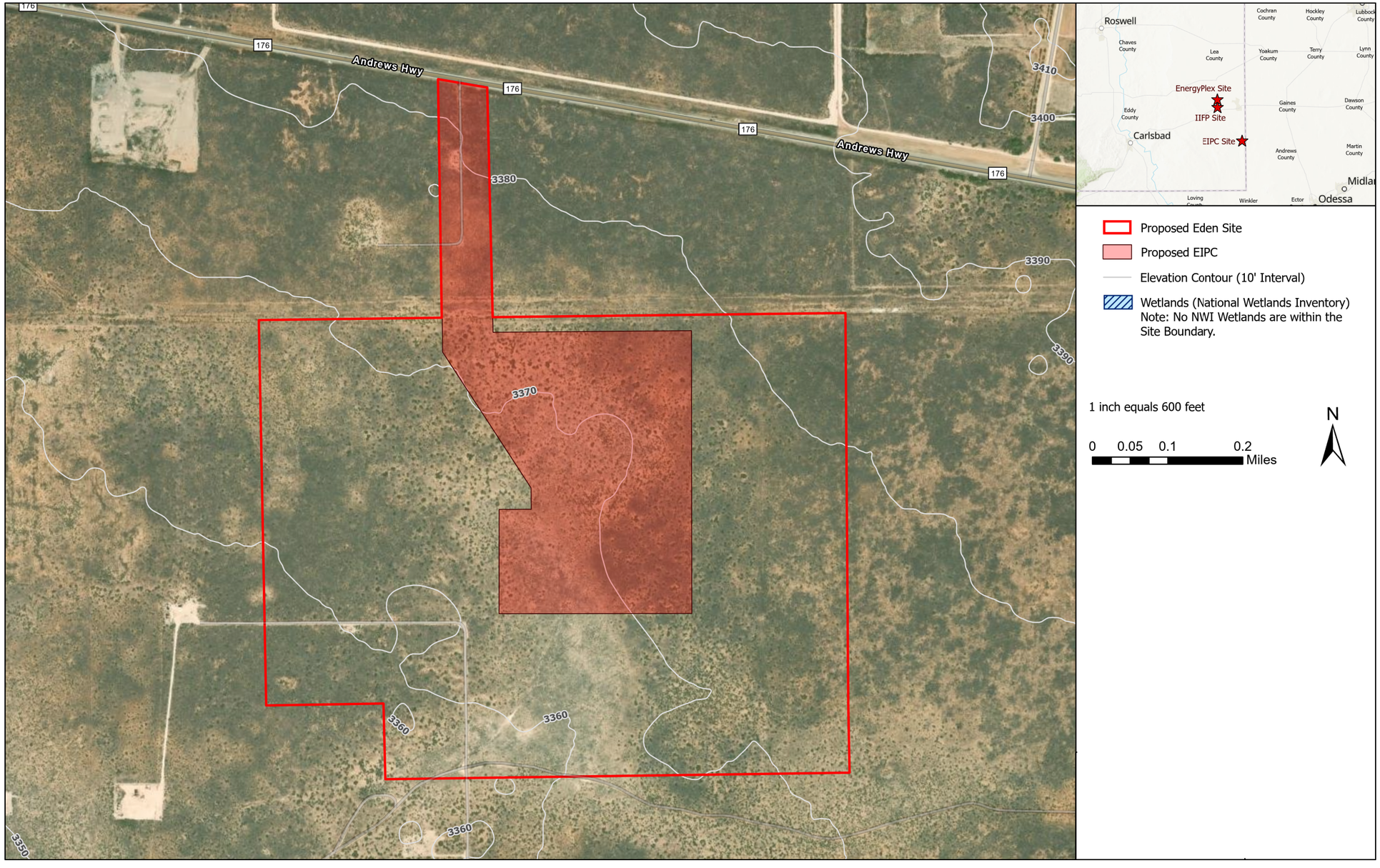

Figure 19.5.2-3
Site Map of the EnergyPlex Park Site

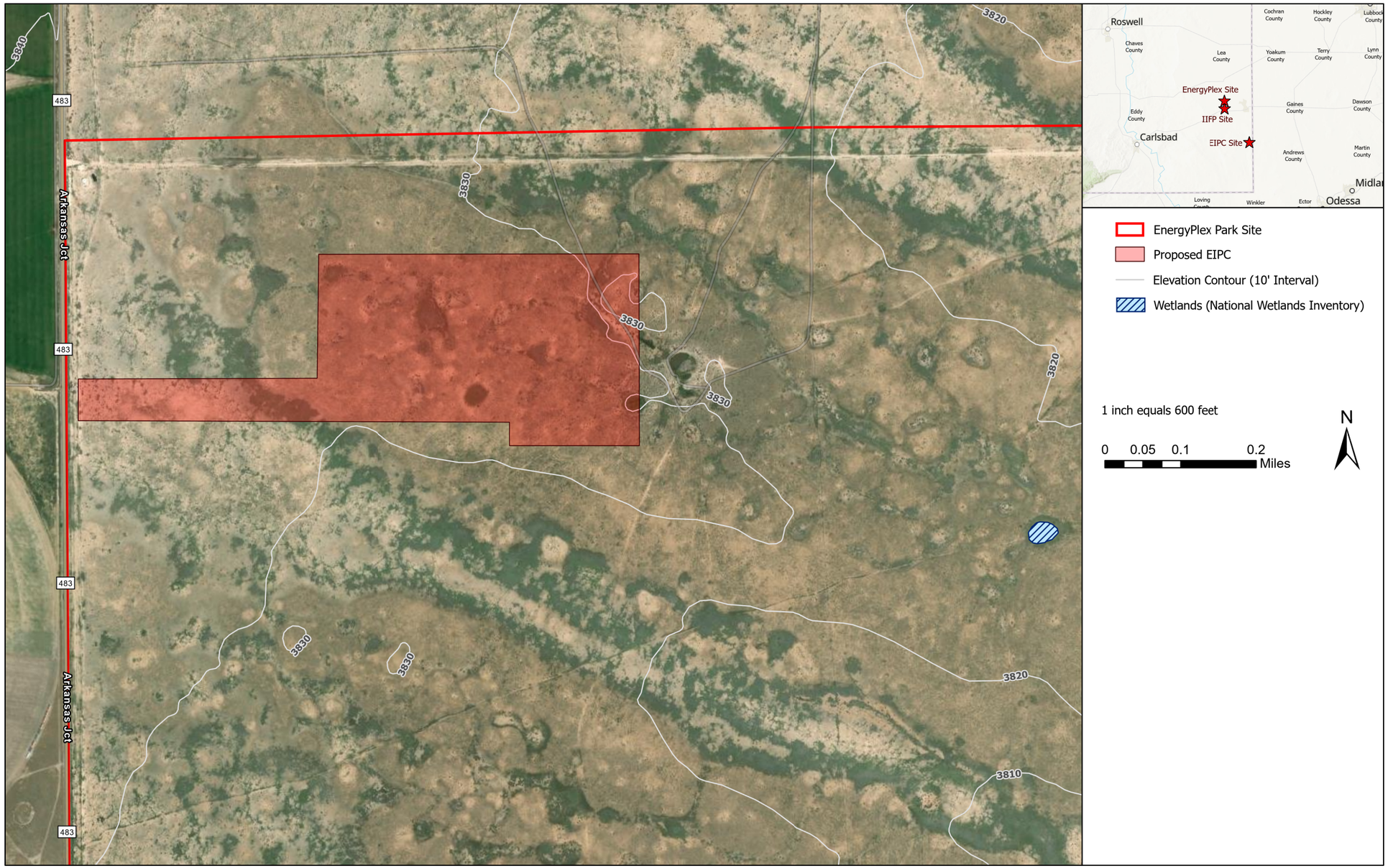

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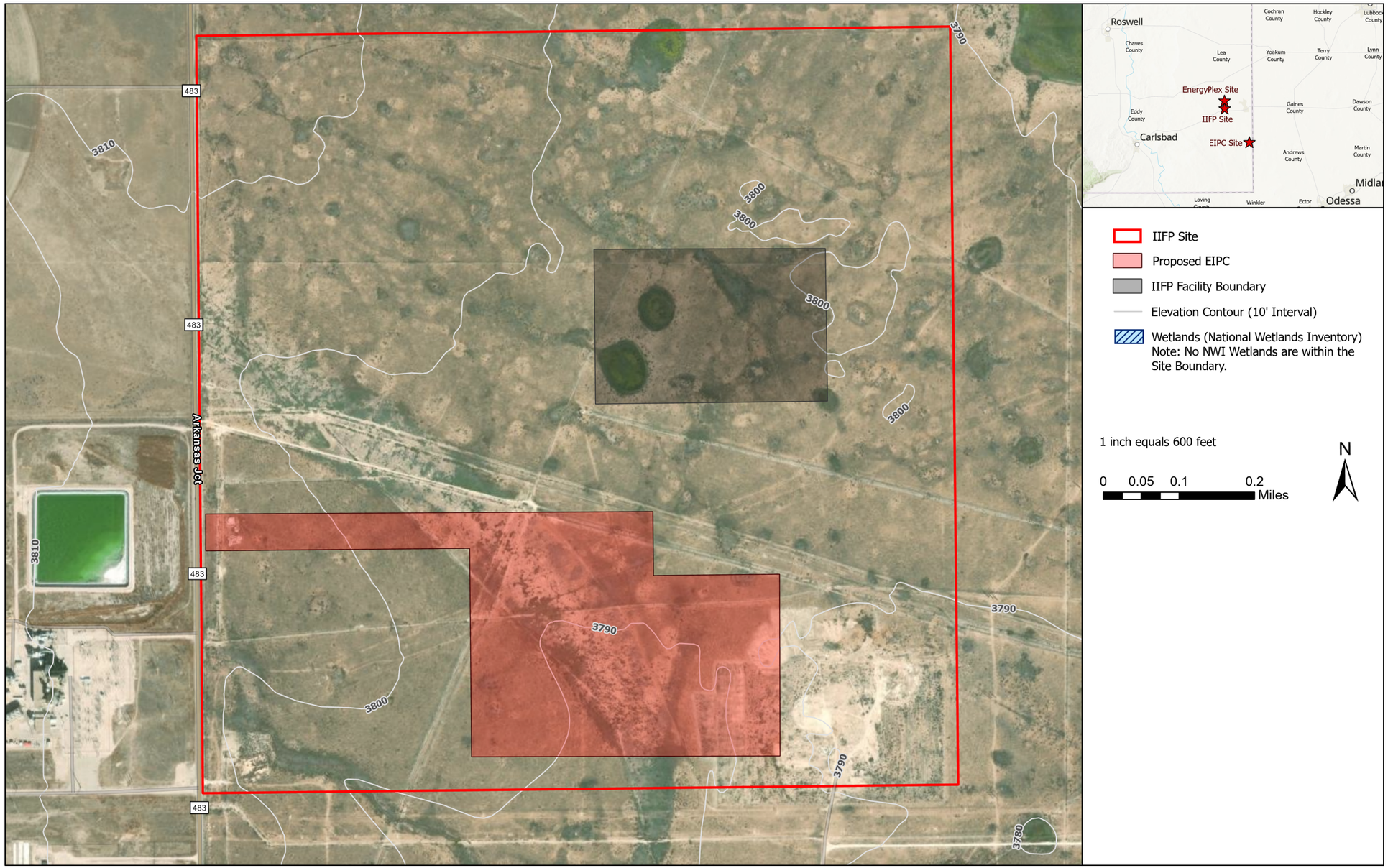
Figure 19.5.2-4
Site Map of the IIFP Site



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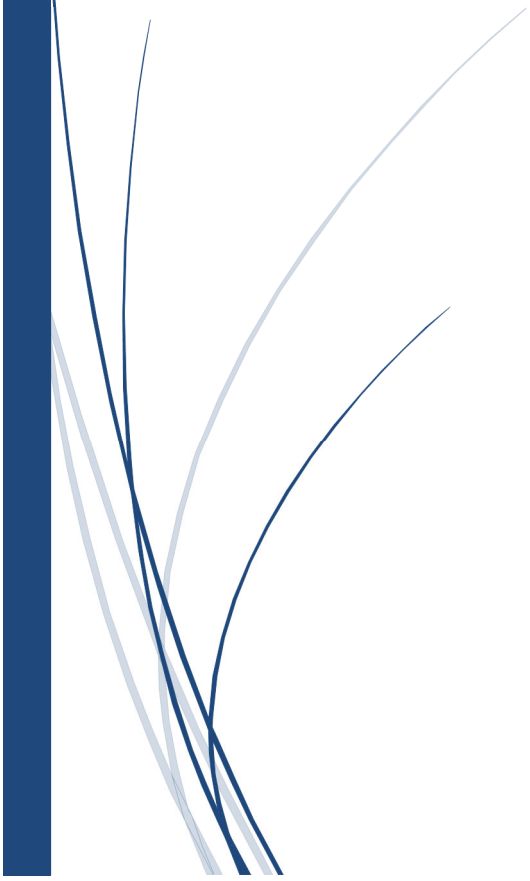
Eden Isotope Production Complex
Preliminary Safety Analysis Report

March 2026
Revision 0

Chapter 19
Environmental Report

Section 19.6
Conclusions



eden | Precision Science. Human Impact.

CHAPTER 19
ENVIRONMENTAL REPORT

SECTION 19.6 CONCLUSIONS

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
Eden	Eden Radioisotopes, LLC
EIPC	Eden Isotope Production Complex

19 Environmental Report

19.6 CONCLUSIONS

19.6.1 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

This section describes principal unavoidable adverse environmental impacts for which mitigation measures either do not exist or cannot eliminate the impact. Because environmental impacts associated with decommissioning are bounded by either plant construction or plant operation, decommissioning is not separately evaluated in this section.

19.6.1.1 Unavoidable Adverse Environmental Impacts of Construction

Although construction of the Eden Isotope Production Complex (EIPC) involves converting undeveloped scrub/shrub land to industrial use, the environmental impacts of construction are minimal. Impacts associated with the construction, operation, and decommissioning of the EIPC assessed in Section 19.4 are SMALL because they either are not detectable or are minor compared to the availability or status of the affected resources.

While the environmental impacts associated with plant construction are SMALL, some small adverse impacts remain after all practical measures to avoid or mitigate them are taken, as noted in Section 19.4. Unavoidable adverse impacts from construction of the facility include:

- Activities such as earthmoving, excavation, pile driving, erection, batch plant operation, and construction-related traffic generate potential disturbances to land use during the construction phase. Construction permanently converts 55.7 acres (22.5 hectares) currently designated as developed low-intensity land use and scrub/shrub use to industrial facility use.
- Construction of EIPC requires consumption from the City of Eunice municipal water supply. The supply draws water from the High Plains Aquifer within the Lea County Underground Water Basin. Based on projected water demand, the total capacity for the Eunice municipal water supply can accommodate water required for EIPC construction.
- Impacts to social services and traffic patterns due to a potential influx of population are minor. Construction of dedicated acceleration and deceleration lanes mitigates local traffic congestion associated with the EIPC entrance.
- Although waste minimization practices will be in place, there are potential minor impacts to the capacity of waste disposal facilities managing construction waste.
- Activities associated with the use of construction and staging equipment and construction workforce traveling to and from the project site can result in varying, minor amounts of dust, air emissions, noise, and vibration.

19.6.1.2 Unavoidable Adverse Environmental Impacts of Operations

Impacts due to the operation of the facility are discussed in detail in Section 19.4. Operations-related impacts are SMALL because they either are not detectable or are minor compared to the availability or status of the affected resource. Operation of the EIPC has no negative effect on land use, ecological resources, or historic and cultural resources.

While the environmental impacts associated with plant operation are SMALL, some small adverse impacts remain after all practical measures to avoid or mitigate them are taken, as noted in Section 19.4. Unavoidable adverse impacts from operation of the facility include:

- Ambient noise levels can be impacted by equipment from the facility and increased vehicle traffic from the EIPC workforce.
- There is minor impact to water supply and sanitary treatment systems. The City of Eunice has ample capacity to provide the water required for the facility. Eunice public works has ample capacity to treat the volume of sanitary waste required for operations.
- There are small impacts to social services because of the small increase in local population due to operations staff moving to the area. There is a small, positive, socioeconomic impact from increased tax revenue and local expenditures by the EIPC operations staff.
- There are potential minor impacts to the general public and operations workforce from radiation sources and airborne radioactive effluents. Additionally, there are potential minor impacts because of exposure to physical, electrical, and chemical hazards at the facility.
- There are potential minor impacts to the capacity of waste disposal facilities managing low-level radioactive waste.

19.6.2 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

This Environmental Report analyzes environmental impacts from activities during plant construction, operation, and decommissioning and draws conclusions about the size of these impacts. For purposes of this section, construction, operation, and decommissioning of the EIPC are considered short-term uses. Long-term productive uses are those that may occur after facility decommissioning at the site is completed. This section includes an evaluation of the extent that environmental impacts from short-term uses preclude any options for future long-term uses of the site.

Subsection 19.6.1.1 summarizes the potential unavoidable adverse environmental impacts of construction. Some small adverse environmental impacts can remain after all practical measures to avoid or mitigate them are taken; however, none of these impacts represent long-term effects that preclude any options for future use of the EIPC site.

Similarly, Subsection 19.6.1.2 summarizes the unavoidable adverse environmental impacts of facility operations. Some small adverse environmental impacts can remain after all practical measures to avoid or mitigate them are taken; however, none of these impacts represent long-term effects that preclude any options for future use of the EIPC site.

During operation, exposures to and management of radioactive and hazardous materials and waste are unavoidable; however, as explained in Sections 19.4.8 and 19.4.11, adherence to exposure and dose limits established by regulatory agencies and implementation of a robust facility health and safety program limits impacts to workers and to the public. EIPC design, engineering controls, and management safety practices are applied to keep worker exposure below the regulatory limits. As stated in Section 19.4.10, exposures to radioactive materials during transportation are also unavoidable; however, the dose impacts to the exposed populations are only a small fraction of background dose.

In summary, the impacts resulting from the facility construction, operation, and decommissioning result in both adverse and beneficial short-term impacts. The principal short-term adverse impacts are SMALL, consisting of minimal impacts to local traffic, noise, and water consumption. There are no long-term impacts to the environment. The principal short-term benefits are the creation of additional jobs and generation of additional tax revenues. The principal long-term benefit is the knowledge and skills acquired by a new generation of scientists and engineers from work at the EIPC. The short-term impacts and benefits and long-term benefits do not affect long-term, productive use of the EIPC site.

19.6.3 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

This section describes the anticipated irreversible and irretrievable commitments of environmental resources used in the construction, operation, and decommissioning of the facility. The term “irreversible commitments of resources” describes environmental resources that are changed by the new facility construction or operation and that cannot be restored to the condition in which the resource existed before construction or operation of the facility. Irretrievable commitments of resources are materials used for the proposed facility in such a way that they cannot, by practical means, be recycled or restored for other uses. These are considered irretrievably committed because their reuse for some other purpose would be highly unlikely.

Irreversible environmental resource commitments resulting from the new facility include consumption of water resources. The proposed facility requires water from the City of Eunice for construction, potable water, fire protection, and facility heating and cooling. Eunice provides water supply for both public drinking and fire protection through treatment of groundwater. As described in Section 19.4.4, because there is sufficient capacity within the municipal water supply system, there are no indirect effects associated with the demand from the facility. There are no direct impacts to water quality or hydrology from the facility; therefore, there are no irreversible impacts.

Construction and decommissioning activities also create irreversible environmental resource commitments to air quality from dust and other emissions, such as vehicle exhaust. Section 19.4.2 contains details on air quality impacts. During operation, emissions are a product of vehicle exhaust, ventilation system exhaust, and fuel combustion, resulting in very low levels of gaseous pollutants and particulates released from the facility into the air. Emissions during operation follow applicable federal and state regulations, minimizing their impact on public health and the environment.

Irretrievable commitments of resources during new facility construction are like that of any small-scale industrial facility construction project. Materials consumed during construction and operation are described in Subsection 19.2.1.6. These materials are irretrievable unless they are recycled at decommissioning. Use of construction materials in the quantities associated with the facility has a SMALL impact with respect to the commitment of such resources.

During operation, the main resources that are irretrievably committed are the nuclear source materials used for medical isotope production. Although much of this material may be processed on-site into new targets, the waste products are irretrievable. Materials used in the construction of the reactor, as well as waste containers and metals and concrete activated as a result of reactor operations, are also irretrievable and are disposed of as radioactive waste. While a given quantity of material consumed during facility construction, operation, and

decommissioning at the site is irretrievable, the impact on material availability is SMALL as the quantity of required materials, mostly concrete and structural steel, is relatively small.

19.6.4 REFERENCES

None.

APPENDIX 19A

REGULATORY CONSULTATION CORRESPONDENCE FOR THE EDEN FACILITY IN LEA COUNTY, NEW MEXICO

APPENDIX 19A REGULATORY CONSULTATION CORRESPONDENCE

The following documents are included in this appendix:

1. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Mr. Michael Sloane (New Mexico Department of Game and Fish), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

2. Email dated February 21, 2023 from Ronald Kellermueller (New Mexico Department of Game and Fish) to James Saldarini (Eden Radioisotopes). Subject: RE: Re: Follow-up to Eden Radioisotopes, LLC Letter dated September 30, 2022. (4 pages).

3. Letter dated December 15, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to David Yoskowitz (Texas Parks and Wildlife Department), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (6 pages).

4. Letter dated January 23, 2023 from Rick Hanson (Ecological and Environmental Planning Program, Wildlife Division, Texas Parks and Wildlife Department) to Mr. Chris Wagner (Eden Radioisotopes, LLC), Re: Potential Site for a Proposed Medical Isotope Production Facility in Lea County, NM. (2 pages)

5. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Director Amy Lueders (Regional Director, Southwest Division, U.S. Fish and Wildlife Service), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

6. Email dated November 29, 2022 from Melissa Fry (Fish and Wildlife Biologist, New Mexico Ecological Field Office) to Chris Wagner (Eden Radioisotopes, LLC). Subject: Review – Proposed Medical Isotope Production Facility. (1 page).

7. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Dr. Jeff Pappas (State Historic Preservation Officer), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

8. Letter dated October 14, 2022 from Michelle M. Ensey (Deputy State Historic Preservation Officer) to Chris Wagner (Eden Radioisotopes, LLC), Re: Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (1 page)

9. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Durell Cooper, Chairman (Apache Tribe of Oklahoma), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

10. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Mark Woommavovah, Chairman, and Ms. Martina Minthorn, Tribal Historic Preservation Officer (Comanche Nation of Oklahoma), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

11. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Lawrence SpottedBird, Chairman (Kiowa Tribe), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

12. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Bernard F. Barcena Jr., Chairman (Lipan Apache Tribe), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

13. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Eddie Martinez, President, and Ms. Holly Houghton, Tribal Historic Preservation Office (Mescalero Tribe), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

14. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Izzy Whitetail Ramirez, Chairman (Texas Band of Yaqui Indians), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

15. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Russell L. Martin, President (Tonkawa Tribe of Oklahoma), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

16. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to Terri Parton, President (Wichita and Affiliated Tribes), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

17. Letter dated September 30, 2022 from Chris Wagner, CEO (Eden Radioisotopes, LLC) to E. Michael Silvas, Governor (Yaleta del Sur Pueblo), Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico. (2 pages).

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Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-001
September 30, 2022

New Mexico Department of Game and Fish
One Wildlife Way
Santa Fe, NM 87507

Attention: Michael Sloane, Director

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Director Sloane:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the New Mexico Department of Game and Fish regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

From: Jim Saldarini <jsaldarini@edenrad.com>
Date: Tuesday, February 21, 2023 at 2:34 PM
To: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>
Subject: Re: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Ron,

Thank you for your valuable input. Much appreciated.

Sincerely,
Jim

James C. Saldarini
Licensing Director
Eden Radioisotopes, LLC
jsaldarini@edenrad.com
(240) 344-5204 mobile

From: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>
Date: Tuesday, February 21, 2023 at 11:35 AM
To: Jim Saldarini <jsaldarini@edenrad.com>
Subject: RE: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Hi Jim,
The New Mexico Department of Game and Fish (Department) has reviewed the proposed Medical Isotope Production Facility Project in Lea, New Mexico submitted by Eden Radioisotopes, LLC. The Department provides the following recommendations to minimize any potential impacts to wildlife during the construction phase of the project.

All migratory birds are protected against direct take under the federal Migratory Bird Treaty Act (16 U.S.C. Sections 703-712). In addition, hawks, falcons, vultures, owls, songbirds, and other insect-eating birds are protected from take under New Mexico State Statutes (17-2-13 and 17-2-14 NMSA), unless permitted by the applicable regulatory agency. To minimize the likelihood of adverse impacts to migratory bird nests, eggs or nestlings during project construction activities, the Department recommends that ground disturbance and vegetation removal activities be conducted outside of the primary breeding season for migratory songbirds and raptors (1 March – 1 September; 1 January-15 July for golden eagle and great horned owl). If ground disturbing and clearing activities must be conducted during the breeding season, the area should be surveyed for active nest sites (with birds or eggs present in the nesting territory), and avoid disturbing active nests until young have fledged. For active nests, establish adequate buffer zones to minimize disturbance to nesting birds. Buffer distances should be a minimum of 100 feet from songbird and raven nests, and 0.25 miles from most raptor nests; and 0.5 miles for ferruginous hawk, golden eagle, peregrine falcon and prairie falcon nests. Active nest sites in trees or shrubs that must be removed should be mitigated by qualified biologists or wildlife rehabilitators. Department biologists are available to consult on nest site mitigation and can facilitate contact with qualified personnel.

Burrowing owls (*Athene cunicularia)* may occur within your project area. Before any ground disturbing activities occur, the Department recommends that a preliminary burrowing owl survey be conducted by a qualified biologist using the Department's burrowing owl

survey protocol. Should burrowing owls be documented in the project area, please contact the Department or USFWS for further recommendations regarding relocation or avoidance of impacts.

Prairie dog colonies may occur within the vicinity of your project area. Both black-tailed prairie dogs (*Cynomys ludovicianus*) and Gunnison's prairie dogs (*Cynomys gunnisoni*) are designated as New Mexico Species of Greatest Conservation Need, and their colonies provide important habitat for other grassland wildlife. Wherever possible, occupied prairie dog colonies should be left undisturbed, and all project activities should be directed off the colony. Any burrows that are located on the project site should be surveyed by a qualified biologist to determine whether burrows are active or inactive and whether burrowing owls may be utilizing the site. Colonies within the range of the black-tailed prairie dog can be surveyed by a qualified biologist diurnally, year-round using binoculars. Colonies within the range of the Gunnison's prairie dog can be surveyed by a qualified biologist diurnally, using binoculars during the warmer months from April through October and by searching for fairly fresh scat and lack of cobwebs or debris at the mouths of burrows during the cold months (November through March). If ground-disturbing activities cannot be relocated off the prairie dog colony, or if project activities involve control of prairie dogs, the Department recommends live-trapping and relocation of prairie dogs. The Department can provide recommendations regarding suitability of potential translocation areas and procedures.

For post-construction reclamation of the project area, the Department recommends that the project proponent use only native plant species and that the reclamation seed mix is designed to enhance local pollinator habitat. The Department also recommends that only certified weed-free seed be used to avoid inadvertently introducing non-native species to the reclamation site. Any alternate seeds used to substitute for primary plant species that are unavailable at the time of reclamation should also be native. When possible, the Department recommends using seeds that are sourced from the same region and habitat type as the reclamation site or from a region that represents potential future climatic conditions at the site.

With the implementation of these recommendations during project construction, the Department does not anticipate significant impacts to wildlife or sensitive habitats.

Thank you for the opportunity to review your proposed project. Please do not hesitate to contact me if you have any questions.

Yours Truly, Ron

RON KELLERMUELLER
MINING AND ENERGY HABITAT SPECIALIST
ECOLOGICAL AND ENVIRONMENTAL PLANNING DIVISION
NEW MEXICO DEPARTMENT OF GAME AND FISH
1 WILDLIFE WAY
SANTA FE, NM 87507
(505) 270-6612
Ronald.Kellermueller@dgf.nm.gov

Conserving New Mexico's Wildlife for Future Generations

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From: Jim Saldarini <jsaldarini@edenrad.com>
Sent: Monday, February 13, 2023 3:17 PM
To: Kellermueller, Ronald, DGF <Ronald.Kellermueller@dgf.nm.gov>
Subject: Re: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Ron,

We are directly across the highway from URENCO. Attached is a photo of our proposed site from the highway.

Regards,
Jim

From: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>
Date: Monday, February 13, 2023 at 4:41 PM
To: Jim Saldarini <jsaldarini@edenrad.com>
Subject: RE: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Hi Jim,
Thanks for sending this. I figured that the facility would likely be located near URENCO. At first glance, project development should not

significantly impact wildlife or sensitive habitats. I will review it more closely and provide comments to minimize potential impacts to wildlife. Our Department archeologist is out on sick leave, when he returns I will seek his feedback as well.

Thanks, Ron

RON KELLERMUELLER
MINING AND ENERGY HABITAT SPECIALIST
ECOLOGICAL AND ENVIRONMENTAL PLANNING DIVISION
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Conserving New Mexico's Wildlife for Future Generations

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From: Jim Saldarini <jsaldarini@edenrad.com>
Sent: Monday, February 13, 2023 2:28 PM
To: Kellermueller, Ronald, DGF <Ronald.Kellermueller@dgf.nm.gov>
Subject: FW: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Third email - EIPC_1.6 Km Boundary Map.

From: Jim Saldarini <jsaldarini@edenrad.com>
Date: Monday, February 13, 2023 at 4:22 PM
To: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>
Subject: FW: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Second email – Cultural Resources Study – please refer to the attachment

---

From: Jim Saldarini <jsaldarini@edenrad.com>
Date: Monday, February 13, 2023 at 4:19 PM
To: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>
Subject: FW: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Ron,

Please refer to the attachment. This was our initial (hard copy) letter to Director Sloane mailed last September. I have attachments to this letter, but the file sizes are large. I will try to send them in separate emails.

Please let me know if you have any questions.

Regards,

James C. Saldarini
Licensing Director
Eden Radioisotopes, LLC
jsaldarini@edenrad.com
(240) 344-5204 mobile

From: "Wunder, Matthew, DGF" <Matthew.Wunder@dgf.nm.gov>
Date: Monday, February 13, 2023 at 4:03 PM
To: Jim Saldarini <jsaldarini@edenrad.com>

Cc: "Kellermueller, Ronald, DGF" <Ronald.Kellermueller@dgf.nm.gov>, "Seamster, Virginia, DGF" <Virginia.Seamster@dgf.nm.gov>
Subject: RE: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

Jim,
Please send it to Ron Kellermueller who was copied on the email.
Thanks,
Matt

From: Jim Saldarini <jsaldarini@edenrad.com>
Sent: Monday, February 13, 2023 2:02 PM
To: Wunder, Matthew, DGF <Matthew.Wunder@dgf.nm.gov>
Cc: Seamster, Virginia, DGF <Virginia.Seamster@dgf.nm.gov>; Kellermueller, Ronald, DGF <Ronald.Kellermueller@dgf.nm.gov>
Subject: [EXTERNAL] Re: Follow-up to Eden Radioisotopes, LLC letter dated September 30, 2022

CAUTION: This email originated outside of our organization. Exercise caution prior to clicking on links or opening attachments.

Matt,

I am on the website. I would like to send you our original letter to Director Sloane, including a few large size attachments. May I use your email address shown on the website?

Thanks!
Jim

James C. Saldarini
Licensing Director
Eden Radioisotopes, LLC
jsaldarini@edenrad.com
(240) 344-5204 mobile

EDEN RADIOISOTOPES

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2212-001
December 15, 2022

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744

Attention: David Yoskowitz, Ph.D., Executive Director

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Director Yoskowitz:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Texas Parks and Wildlife Department (TPWD) regarding potential for species of concern and their related habitat to be adversely impacted by the proposed project. This request is being made pursuant to the Texas Administrative Code (Sections 65.175 and 65.176) and other applicable state regulations. We are making this request in order to identify notable environmental resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by January 31, 2023. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are attached.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

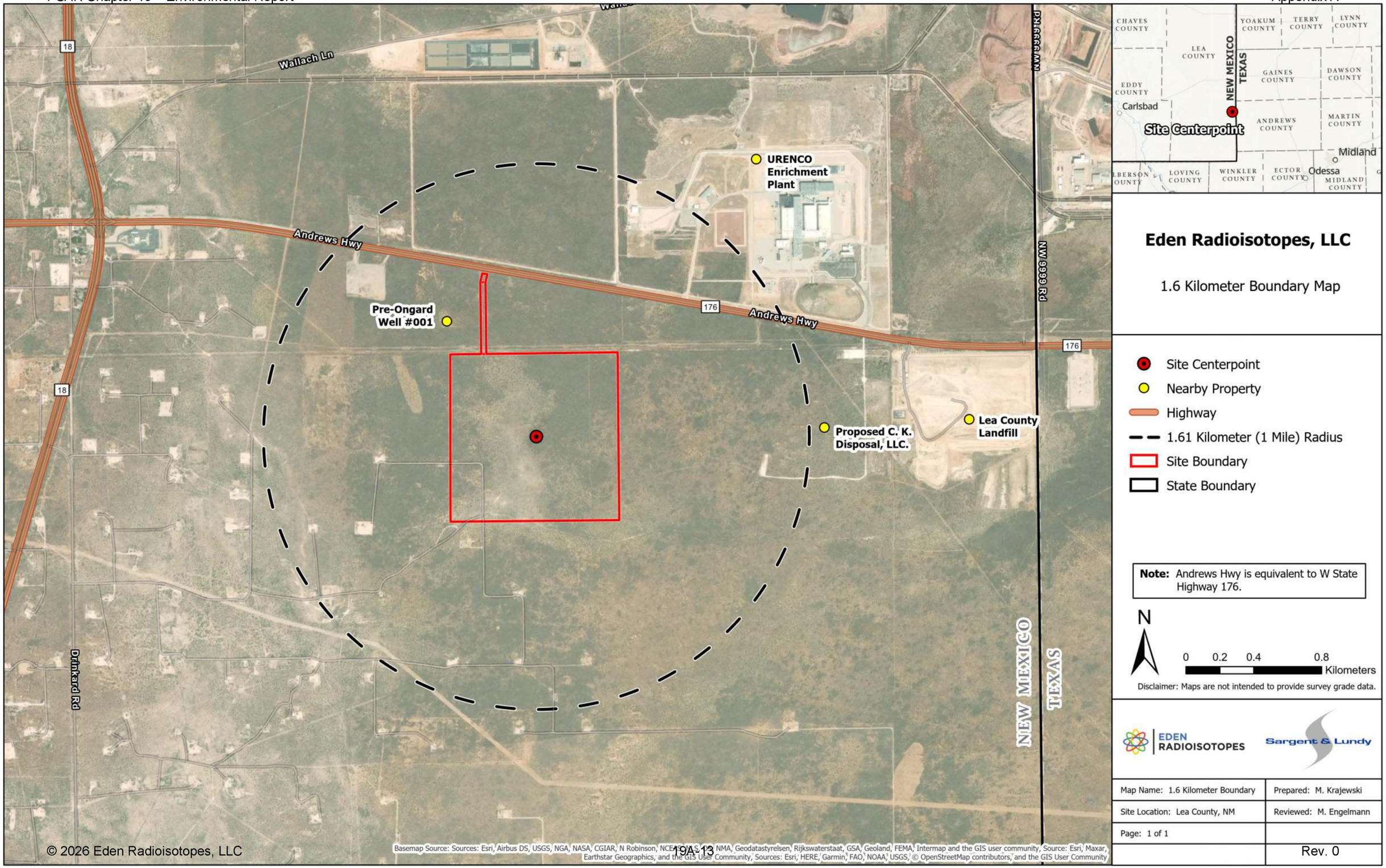
Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Enclosure

Eden Radioisotopes, LLC

Eden Isotope Production Complex

Boundary Map
1.6 kilometer radius



Eden Radioisotopes, LLC

1.6 Kilometer Boundary Map

- Site Centerpoint
- Nearby Property
- Highway
- 1.61 Kilometer (1 Mile) Radius
- Site Boundary
- State Boundary

Note: Andrews Hwy is equivalent to W State Highway 176.

N

0 0.2 0.4 0.8 Kilometers

Disclaimer: Maps are not intended to provide survey grade data.

EDEN RADIOISOTOPES

Sargent & Lundy

Map Name: 1.6 Kilometer Boundary	Prepared: M. Krajewski
Site Location: Lea County, NM	Reviewed: M. Engelmann
Page: 1 of 1	
	Rev. 0

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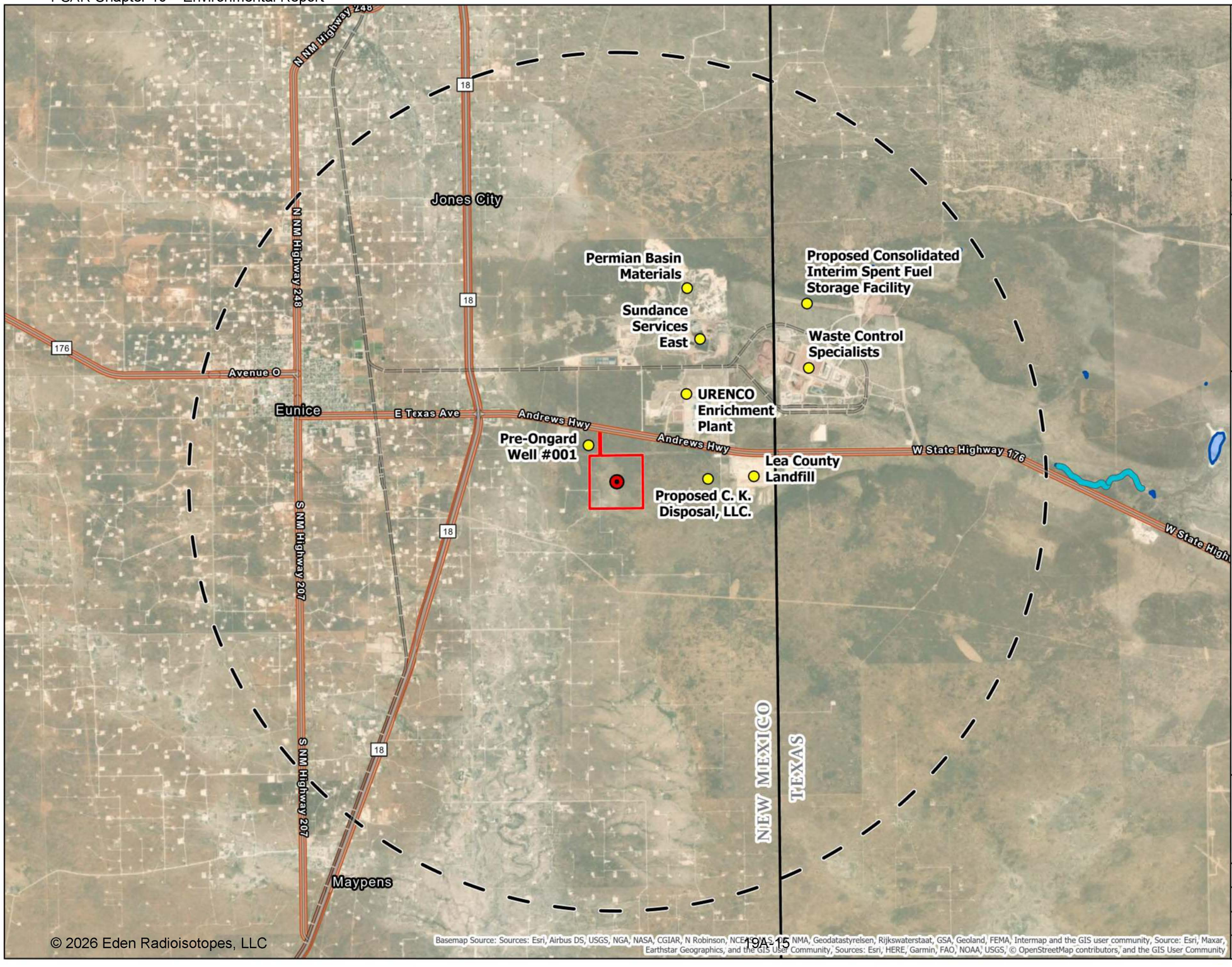
Basemap Source: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

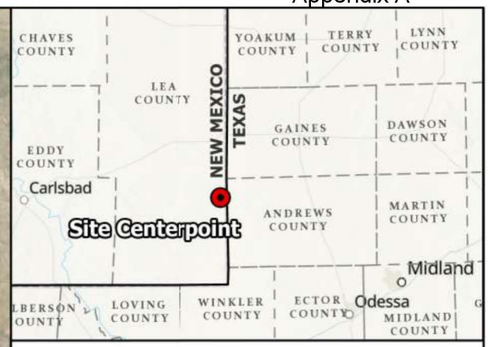
Enclosure

Eden Radioisotopes, LLC

Eden Isotope Production Complex

Boundary Map
8 kilometer radius





Eden Radioisotopes, LLC

8 Kilometer Boundary Map

- Site Centerpoint
- Nearby Property
- Highway
- 8 Kilometer (4.97 Mile) Radius
- State Boundary
- Site Boundary
- National Hydrology Dataset (NHD) Intermittent or Perennial Lake/Pond
- NHD Intermittent Stream

Note: Andrews Hwy is equivalent to W State Highway 176.

N

0 0.75 1.5 3 Kilometers

Disclaimer: Maps are not intended to provide survey grade data.

EDEN RADIOISOTOPES

Sargent & Lundy

Map Name: 8 Kilometer Vicinity	Prepared: M. Krajewski
Site Location: Lea County, NM	Reviewed: M. Engelmann
Page: 1 of 1	
	Rev. 0

TEXAS PARKS & WILDLIFE

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Commissioners

Arch "Beaver" Aplin, III
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Lee M. Bass
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Fort Worth

T. Dan Friedkin
Chairman-Emeritus
Houston

David Yoskowitz, Ph.D.
Executive Director

January 23, 2023

Mr. Chris Wagner
Eden Radioisotopes, LLC
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122

RE: Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico

Dear Mr. Wagner:

Texas Parks and Wildlife Department (TPWD) has received the request for information regarding the proposed project listed above. TPWD staff has reviewed the information provided and offers the following comments concerning this project.

In addition to state and federally protected species, TPWD tracks species considered to be Species of Greatest Conservation Need (SGCN) that, due to limited distributions or declining populations, face threat of extirpation or extinction but currently lack the legal protections given to threatened or endangered species. Special landscape features, natural plant communities, and SGCN are rare resources for which TPWD actively promotes conservation, and TPWD considers it important to minimize impacts to such resources to reduce the likelihood of endangerment and preclude the need to list SGCN as threatened or endangered in the future. These species and communities are tracked in the Texas Natural Diversity Database (TXNDD). The most current and accurate rare and protected species data for Andrews County, Texas can be requested from the TXNDD website.

Please note that the absence of TXNDD information in the proximity does not imply that a species is absent from that area. Given the small proportion of public versus private land in Texas, the TXNDD does not include a representative inventory of rare resources in the state. Although it is based on the best data available to TPWD regarding rare and protected species, data from the TXNDD does not provide a definitive statement as to the presence, absence or condition of special species, natural communities, or other significant features within a project area. These data are not inclusive and cannot be used as presence/absence data or be substituted for on the ground surveys.

If suitable habitat is available, rare and protected species could be present within the Texas portion of 8-kilometer project boundary radius. Please review the TPWD county list for Andrews County which can be found on the Rare, Threatened, and Endangered Species of Texas website.

4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744-3291
512 389-4800
www.tpwd.texas.gov

To manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations.

Mr. Chris Wagner
Page 2
January 23, 2023

The TPWD Landscape Ecology Program has developed an interactive mapping application, the Texas Ecosystem Analytical Mapper (TEAM), to assist wildlife biologists, land managers, naturalists, planners, and conservationists in understanding Texas habitats and to integrate vegetation data with land management and resource planning of all types. For more information on TEAM please visit the TPWD Landscape Ecology Program website.

Future correspondence regarding this project can be submitted to WHAB@tpwd.texas.gov. Please contact me at Richard.Hanson@tpwd.texas.gov or (806) 761-4930 ext. 4936 if you have any questions.

Sincerely,

Rick Hanson

Rick Hanson
Ecological and Environmental Planning Program
Wildlife Division

RH: 49830

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-003
September 30, 2022

U.S. Fish and Wildlife Service Southwest Region
500 Gold Ave. SW
Albuquerque, NM 87102

Attention: Amy Lueders, Regional Director, Southwest Region

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Director Lueders:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the U.S. Fish and Wildlife Service (USFWS) regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

From: "Fry, Melissa N" <melissa_fry@fws.gov>
Date: Tuesday, November 29, 2022 at 1:07 PM
To: Chris Wagner <cwagner@edenrad.com>, Jim Saldarini <jsaldarini@edenrad.com>, "maria.albright@sargentlundy.com" <maria.albright@sargentlundy.com>
Subject: Review - Proposed Medical Isotope Production Facility Site

Good morning,

Thank you for letting us review the project. We have no specific comments at this time, but we do recommend that you use the IPaC website (https://ipac.ecosphere.fws.gov/) when developing your ER. Please reach back out if there are any changes to the project or you have any questions.

Thank you! Have a great rest of your week.

Melissa Fry
Fish and Wildlife Biologist
New Mexico Ecological Services Field Office
Energy Team - Roswell BLM Office
Work Cell Phone: 505-414-0030
Office Phone: 575-627-0206

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

EDEN-LTR-2209-002
September 30, 2022

New Mexico Historic Preservation Division, Department of Cultural Affairs
407 Galisteo Street, Suite 236
Santa Fe, NM 87501

Attention: Jeff Pappas, PhD., State Historic Preservation Officer

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Dr. Pappas:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.3 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

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To support preparation of the ER, we are requesting comment and information from the New Mexico Historic Preservation Division, Department of Cultural Affairs regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

STATE OF NEW MEXICO
DEPARTMENT OF CULTURAL AFFAIRS
HISTORIC PRESERVATION DIVISION

BATAAN MEMORIAL BUILDING
407 GALISTEO STREET, SUITE 236
SANTA FE, NEW MEXICO 87501
PHONE (505) 827-6320 FAX (505) 827-6338

October 14, 2022

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122

Re: Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico

Dear Mr. Wagner:

I am responding to your request for information and comment on the proposed medical isotope production facility and the cultural resource survey report for the facility that was provided by NV5. I have reviewed the report and have no concerns regarding the findings.

Currently, I have no other comments or information to provide on the proposed facility. Because the facility will be licensed by the Nuclear Regulatory Commission (NRC) the NRC must consult with this office and request concurrence with an effect determination based on the cultural resources survey report and the results of their consultation with Native American Tribes. Native American tribes have special expertise to identify traditional cultural properties or areas that may have hold significance to them that the archaeologist is not able to identify. Consultation with the tribes cannot be delegated under Section 106 of the National Historic Preservation Act and is conducted government-to-government.

Please do not hesitate to contact me if you have any questions or concerns. I can be reached by telephone at (505) 827-4064 or by email at michelle.ensey@dca.nm.gov.

Sincerely,

Michelle M. Ensey
Deputy State Historic Preservation Officer
& State Archaeologist

Log: 118096

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-004
September 30, 2022

Apache Tribe of Oklahoma
P.O. Box 1330
Anadarko, OK 73005

Attention: Durell Cooper, Chairman

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Chairman Cooper:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Apache Tribe of Oklahoma regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-005
September 30, 2022

Comanche Nation of Oklahoma
P.O. Box 908
Lawton, OK 73502

Attention:
Mark Woommavovah, Chairman
Ms. Martina Minthorn, Tribal Historic Preservation Officer

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Chairman Woommavovah and Officer Minthorn:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

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Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

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To support preparation of the ER, we are requesting comment and information from the Comanche Nation of Oklahoma regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

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If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-006
September 30, 2022

Kiowa Tribe
P.O. Box 369
Carnegie, OK 73015-0369

Attention: Lawrence SpottedBird, Chairman

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Chairman SpottedBird:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

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To support preparation of the ER, we are requesting comment and information from the Kiowa Tribe regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-007
September 30, 2022

Lipan Apache Tribe
P.O. Box 5218
McAllen, TX 78502

Attention: Bernard F. Barcena Jr., Chairman

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Chairman Barcena:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Lipan Apache Tribe regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

EDEN RADIOISOTOPES

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-008
September 30, 2022

Mescalero Apache Tribe
P.O. Box 227
Mescalero, NM 88340

Attention: Eddie Martinez, President
Ms. Holly Houghton, Tribal Historic Preservation Office (THPO)

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear President Martinez and Ms. Holly Houghton:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Mescalero Apache Tribe regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-009
September 30, 2022

Texas Band of Yaqui Indians
P.O. Box 12076
Lubbock, Texas 79452

Attention: Izzy Whitetail Ramirez, Chairman

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Chairman Ramirez:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Texas Band of Yaqui Indians regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

EDEN RADIOISOTOPES

Chris Wagner, CEO
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Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-010
September 30, 2022

Tonkawa Tribe of Oklahoma
1 Rush Buffalo Rd.
Tonkawa, OK 74653

Attention: Russell L. Martin, President

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear President Martin:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Tonkawa Tribe of Oklahoma regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-011
September 30, 2022

Wichita and Affiliated Tribes
P.O. Box 729
1 1/4 Miles North on Hwy 281
Anadarko, OK 73005

Attention: Terri Parton, President

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear President Parton:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

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To support preparation of the ER, we are requesting comment and information from the Wichita and Affiliated Tribes regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

EDEN RADIOISOTOPES

Chris Wagner, CEO
9400 Holly Ave. NE, Suite 202
Albuquerque, NM 87122
cwagner@edenrad.com

Letter No. EDEN-LTR-2209-012
September 30, 2022

Ysleta del Sur Pueblo
119 S. Old Pueblo Road,
P.O. Box 17579
El Paso, TX 79907

Attention: E. Michael Silvas, Governor

Subject: **Request for Information and Comment on a Potential Site for a Proposed Medical Isotope Production Facility in Lea County, New Mexico**

Dear Governor Silvas:

Eden Radioisotopes, LLC (Eden), plans to construct and operate the Eden Isotope Production Complex (EIPC) near Eunice, Lea County, New Mexico. The facility is being built for the production of medical isotopes, including Molybdenum-99, Lutetium-177, Iodine-131, and Xenon-133, for medical imaging and radiotherapeutic purposes.

The EIPC will be licensed by the U.S. Nuclear Regulatory Commission (NRC). As required by Title 10 of the Code of Federal Regulations Part 51, *Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions*, Eden is preparing a comprehensive Environmental Report (ER) to provide detailed information to the NRC to facilitate NRC's preparation of an Environmental Assessment or an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. Sargent & Lundy, LLC, has been retained by Eden to assist in the preparation of the ER.

Eden is applying to the NRC for authorization to construct, operate, and decommission the EIPC. The proposed facility includes a 2-megawatt thermal, non-power reactor and hot cell processing facility that will be designed, built, and operated to governing NRC regulations with the goal of reliable and stable medical isotope production. Upon NRC approval, Eden would be authorized to construct, operate, and decommission the EIPC; receive low enriched uranium (LEU) or LEU targets; process LEU targets to extract medical isotope products and reclaim the LEU; fabricate new targets from the reclaimed LEU; transport radioisotope products to end-users; and transport low-level radioactive waste for disposal.

The EIPC will be constructed on an approximately 240-acre (97-ha) tract of undeveloped land situated approximately 1.4 miles (2.2 km) east of the city of Eunice, New Mexico and 1.8 miles (3.0 km) west of the Texas/New Mexico border. The facility will be located within Section 6, Township 22 South, Range 38 East (at approximately 32.4237326 latitude and -103.0961498 longitude). The proposed location consists of undeveloped brush and grassland that has historically been used for cattle grazing and for gas and oil production. Surrounding land use includes other industrial facilities, oil and gas production, and limited cattle grazing.

To support preparation of the ER, we are requesting comment and information from the Ysleta del Sur Pueblo regarding potential impacts to significant historical, environmental, and cultural resources resulting from the proposed project. This request is being made pursuant to the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.); New Mexico Cultural Properties Act (Sections 18-6 through 18-6-23, NMSA 1978); and The Prehistoric and Historic Sites Preservation Act of 1989 (Sections 18-8-1 through 18-8-8, NMSA 1978). For your reference, a Cultural Resource Survey prepared for the project by NV5 Global, Inc. (Issued April 2020; amended August 2022) is enclosed. Note that the Cultural Resource Survey is bounding of the EIPC project site. We are making this request in order to identify notable environmental and cultural resources or issues that should be addressed in the ER and considered in the design, construction, and operation of the proposed EIPC.

A full range of environmental and cultural resources will be considered in the preparation of the ER and as part of the overall licensing process. Eden respectfully requests your input for our consideration in the development of the ER and other licensing application materials. Your response to this request for information would be most appreciated if received by November 30, 2022. To assist your consideration of this request, boundary maps depicting the project site and surrounding area are also enclosed.

If you have any questions or comments, please contact Mr. James Saldarini, Eden Licensing Director, at 240-344-5204 (jsaldarini@edenrad.com) or Ms. Maria Albright, S&L Environmental Specialist, at 312-269-2308 (maria.albright@sargentlundy.com).

Best Regards,

Chris Wagner

Chris Wagner
Chief Executive Officer
Eden Radioisotopes, LLC

Enclosures:
Eden Cultural Resources Survey
EIPC Boundary Map – 1.6-kilometer radius
EIPC Boundary Map – 8-kilometer radius

Copies w/o enclosures:
James Saldarini (Eden)
Matthew Engelmann (S&L)
Maria Albright (S&L)

APPENDIX 19B

A CULTURAL RESOURCE SURVEY FOR THE EDEN FACILITY IN LEA COUNTY, NEW MEXICO

Performing Agency/Consultant: NV5

Report Date April 2020, amended August 2022

NMCRIS INVESTIGATION ABSTRACT FORM (NIAF)

1. NMCRIS Activity No.:	2a. Lead (Sponsoring) Agency:	2b. Other Permitting Agency(ies):	3. Lead Agency Report No.:
145356	SHPO		

4. Title of Report: A Cultural Resouce Survey for the Eden Facility in Lea County, New Mexico

Author(s) Jack Lynn and Toni R. Goar

5. Type of Report ☒ **Negative** ☐ **Positive**

6. Investigation Type

☐ Research Design ☒ Survey/Inventory ☐ Test Excavation ☐ Excavation ☐ Collections/Non-Field Study
☐ Overview/Lit Review ☐ Monitoring ☐ Ethnographic study ☐ Site specific visit ☐ Other

7. Description of Undertaking (what does the project entail?): Eden Radioisotopes, LLC is teaming with Abo Empire, a Yates Family company to build a reactor. The reactor will produce primarily be Molybdenum-99. This isotope is used in medical molecular imaging or nuclear medicine.

The Eden Facility plans to enter production in four years. This cultural resource survey is part of a preliminary fatal flaw analysis for this property. At this time, no federal agency is involved.

8. Dates of Investigation: (from: 2/4/2020 **to:** 2/7/2020 and 3/25 to 3/26/2020)

9. Report Date: April 2020, amended August 2022 to add project UTM location data.

10. Performing Agency/Consultant: NV5
Principal Investigator: Joanne Eakin
Field Supervisor: Jack Lynn, Toni R. Goar
Field Personnel Names: Josh Humiston, Joanne Eakin

11. Performing Agency/Consultant Report No.: 444620-335000A.02

12. Applicable Cultural Resource Permit No(s): NM-20-160-S

13. Client/Customer (project proponent): Pettigrew and Associates
Contact: Bentley Shafer
Address: 100 E. Navajo Dr., Hobbs, NM 88240
Phone: (505) 393-9827

14. Client/Customer Project No.:

15. Land Ownership Status ***(Must be indicated on project map):***

Land Owner	Acres Surveyed	Acres in APE
Private	319.56	291.18
TOTALS	319.56	291.18

16 Records Search(es):

Date(s) of ARMS File Review 1/29/20	**Name of Reviewer(s)** Rob McCall	
Date(s) of NR/SR File Review 1/29/20	**Name of Reviewer(s)** Rob McCall	
Date(s) of Other Agency File Review	**Name of Reviewer(s)**	**Agency**

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17. Survey Data:

a. Source Graphics ☐ NAD 27 ☒ NAD 83

☒ USGS 7.5' (1:24,000) topo map ☐ Other topo map, Scale:

☒ GPS Unit Accuracy ☒ <1.0m ☐ 1-10m ☐ 10-100m ☐ >100m

b. USGS 7.5' Topographic Map Name | **USGS Quad Code**

Eunice NE	32103-D1 (1979)

c. County(ies): Lea

17. Survey Data (continued):

d. Nearest City or Town: Eunice

e. Legal Description:

Township (N/S)	Range (E/W)	Section	¼ ¼ ¼
21S	38E	31, 32	, , .
22S	38E	5, 6	, , .
			, , .
			, , .
			, , .
			, , .
			, , .
			, , .

Projected legal description? Yes ☐ **, No** ☒ **Unplatted** ☐

f. Other Description (e.g. well pad footages, mile markers, plats, land grant name, etc.):

18. Survey Field Methods:

Intensity: ☒ 100% coverage ☐ <100% coverage

Configuration: ☒ block survey units ☐ linear survey units (l x w): ☐ other survey units (specify):

Scope: ☐ non-selective (all sites recorded) ☐ selective/thematic (selected sites recorded)

Coverage Method: ☒ systematic pedestrian coverage ☐ other method (describe)

Survey Interval (m): 15 **Crew Size:** 3 **Fieldwork Dates:** 2/4/2020 to 2/7/2020 and 3/25-3/26/2020

Survey Person Hours: 78 **Recording Person Hours:** 0 **Total Hours:** 78

Additional Narrative: No survey on 2.5.20 due to weather.

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19. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.): The project area is in the southern extension of the Llano Estacado. This area, a portion of the Southern High Plains, is a remnant "of a vast debris apron spread along the eastern front of the mountains of Central New Mexico by streams flowing eastward and southeastward during the Tertiary period" (Turner et al. 1974:84). The Llano Estacado has a nearly flat to undulating surface with a slight gradient to the east and southeast of 3.0 to 4.6 m (10–15 ft) per mile (Turner et al. 1974:85). Elevation of the project area is approximately 1,029 meters (m) (3,375 feet [ft]) above mean sea level (amsl).

Much of the surface is underlain by aeolian and alluvial deposits of the Ogallala Formation and has a resistant caliche caprock. This caprock zone, a secondary carbonate accumulation, is at or near the surface. Three soil associations dominate the area: Brownfield-Springer association, Gomez loamy fine-sand, and Kermit soils and dune land. Brownfield-Springer association is found on plains at an elevation range of 1,067 m to 1,341 m (3,500 ft to 4,400 ft) amsl. The parent material is eolian deposits derived from sedimentary rock. Gomez loamy fine-sand is found on plains and in draws with an elevation of 762 m to 1,463 m (2,500 ft to 4,800 ft) amsl. Its parent material is calcareous loamy eolian deposits. Kermit soils and dune land is found in dunes at an elevation range of 914 m to 1,341 m (3,000 ft to 4,400 ft) amsl. Its parent material is calcareous sandy eolian deposits derived from sedimentary rock (US Department of Agriculture Web Soil Survey Data, 2020).

The climate is characterized by moderate rainfall, warm summers, and cool, dry winters. The average annual precipitation in the project area is 30.5 to 40.6 centimeters (cm) (12 to 16 inches). The wettest months are May through October, with May and July through September averaging more than 5.1 cm (2.0 inches). June and July average at least 3.8 cm (1.5 inches) precipitation. Most of the wet period rainfall occurs as brief, heavy thunderstorms and originates in the Gulf of Mexico (Houghton 1974:86). The average annual temperature is 14.3º to 15.4º Celsius (C) (58º to 60º Fahrenheit [F]) (Western Regional Climate Center 2009).

The project area supports primarily disturbed Plains-Mesa Grassland vegetation (Dick-Peddie 1993). Dominant plant species present in the area include blue grama (*Bouteloua gracilis*), black grama (*Bouteloua eriopoda*), snakeweed (*Gutierrezia sarothrae*), tabosagrass (*Pleuraphis mutica*), scarlet globemallow (*Sphaeralcea coccinea*), and tree cholla (*Cylindropuntia imbricata*). Other plants common in the area include prickly pear (*Opuntia* sp.), desert zinnia (*Zinnia acerosa*), side-oats grama (*Bouteloua curtipendula*), and yucca (*Yucca* sp.).

20. a. Percent Ground Visibility: 40 to 80 % **b. Condition of Survey Area (grazed, bladed, undisturbed, etc.):** The project area appears to be fairly undisturbed.

21. CULTURAL RESOURCE FINDINGS ☐ **Yes, See Page 3** ☒ **No, Discuss Why:** Six isolated occurrences were documented; area is flat and areas are rocky..

22. Required Attachments (check all appropriate boxes):
- ☒ **USGS 7.5 Topographic Map with sites, isolates, and survey area clearly drawn**
- ☒ **Copy of NMCRIS Mapserver Map Check**
- ☐ **LA Site Forms - new sites (*with sketch map & topographic map*)**
- ☐ **LA Site Forms (update) - previously recorded & un-relocated sites (*first 2 pages minimum*)**
- ☐ **Historic Cultural Property Inventory Forms**
- ☒ **List and Description of isolates, if applicable**
- ☐ **List and Description of Collections, if applicable**

23. Other Attachments:
- ☐ **Photographs and Log**
- ☐ **Other Attachments**

***(Describe)*:**

24. I certify the information provided above is correct and accurate and meets all applicable agency standards.

Principal Investigator/Responsible Archaeologist: Joanne Eakin

Signature Joanne Eakin **Date** 4.3.2020, revised 8.3.22 **Title (if not PI):**

25. Reviewing Agency:

Reviewer's Name/Date

Accepted ( ) Rejected ( )

Tribal Consultation (if applicable): ☐ **Yes** ☐ **No**

26. SHPO
Reviewer's Name/Date:

HPD Log #:

SHPO File Location:

Date sent to ARMS:

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CULTURAL RESOURCE FINDINGS

[fill in appropriate section(s)]

1. NMCRIS Activity No.: 145356	2. Lead (Sponsoring) Agency: SHPO	3. Lead Agency Report No.:

SURVEY RESULTS:

Sites discovered and registered: 0
Sites discovered and NOT registered: 0
Previously recorded sites revisited (*site update form required*): 0
Previously recorded sites not relocated ***(site update form required):*** 0
TOTAL SITES VISITED: 0
Total isolates recorded: 6 **Non-selective isolate recording?** ☒
Total structures recorded (*new and previously recorded, including acequias*): 0

MANAGEMENT SUMMARY: NV5, Inc. (NV5) completed a 100-percent, intensive, cultural resource survey between February 4 and 7, 2020. The survey was conducted by Jack Lynn, Joshua Humiston, and Joanne Eakin. Joanne Eakin served as the Principal Investigator. Work was conducted under New Mexico State Permit No.20-160-S. Sixty-eight person hours (not including drive time) were required to complete the survey. The State Historic Preservation Officer (SHPO) is the reviewing agency. On March 25 and 26, 2020, Toni Goar conducted an additional survey of 44 acres. Ten person hours were used to survey the additional acreage. The additional acreage was added to the southern portion of the project per the client's instruction.

A total of 319.56 acres [ac] was surveyed on private land. The project area is 291.18 ac and a 100-ft buffer was added to the south, east, and west borders of the project area. A 50-ft buffer was surveyed along the proposed access route (Figures 1 through 3). The Universal Transverse Mercator (UTM) coordinates for the surveyed boundaries are listed in Table 1.

Prior to the cultural resource survey, NV 5 conducted an electronic search of the Museum of New Mexico Archaeological Records Management System (ARMS) on January 29, 2020. No sites are located within 0.5 km (0.3 mi) of the project area. Two cultural resource surveys have been completed within 0.5 km (0.3 mi) of the project area (Table 2; Figure A1). Published listings for the State Register of Cultural Properties (SRCP) and the National Register of Historic Places (NRHP) were consulted. No listed property is near the project area.

Six isolated occurrences were found during the survey (Table 3; Figure A2). The isolated occurrences do not meet the criteria for eligibility to the NRHP. No further treatment is recommended.

This undertaking complies with the provisions of the National Historic Preservation Act (NHPA) of 1966, as amended, and applicable regulations. This report is consistent with applicable federal and state standards for cultural resource management.

In the event that cultural resource materials are uncovered during either construction or earth-disturbing activities, work in the area should cease immediately and the State Historic Preservation Officer (SHPO) will be notified. SHPO will determine the necessary steps to evaluate, document, protect, or remove the material or remains, in compliance with the law.

IF REPORT IS NEGATIVE YOU ARE DONE AT THIS POINT.

References Cited

Dick-Peddie, William A.
1993 *New Mexico Vegetation: Past, Present, and Future.* University of New Mexico Press, Albuquerque.

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Graves, Timothy B.
2004 *An Intensive Cultural Resource Inventory of 543 Acres for the National Enrichment Facility near Eunice, Lea County, New Mexico*. NMCRIS 85083.

Proper, Michael J.
2007 *Cultural Resource Inventory of the Proposed US Cable Project for the National Enrichment Facility near Eunice, Lea County, New Mexico*. NMCRIS 101725.

United States Department of Agriculture, Natural Resources Conservation Service. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov. Accessed February 2020.

Western Regional Climate Center
2009 Monthly Climate Summary. Western Regional Climate Center, Reno. Electronic document accessed February 2009. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm3288

Table 1 — Project UTM Coordinates NAD 83 Zone 13

Location	Easting	Northing
Northwest corner	678254	3589471
Northeast corner	679504	3589499
Southwest corner	678266	3588664
Southeast corner	679522	3588681
Extension northwest	678614	3590012
Extension northeast	678767	3589990
Extension southwest	678629	3589480
Extension southeast	678756	3589483

Additional 44 acres

Northwest – 678481E 3588680N

Southwest – 678498E 3588479 N

Southeast – 679529E 3588494 N

Northeast – 679531E 3588704N

Table 2 — Previous Archaeological Surveys within 0.5 km (0.3 mi) of the Project Area

NMCRIS No.	Description	Acres	No. of Sites	Author, Date
85083	An Intensive Cultural Resource Inventory of 543 Acres for the National Enrichment Facility near Eunice, Lea County, New Mexico	540	7	Graves, Timothy B., 2004
101725	Cultural Resource Inventory of the Proposed US Cable Project for the National Enrichment Facility near Eunice, Lea County, New Mexico	28.84	0	Proper, Michael J., 2007

Table 3 — Isolated Occurrence Summary

IO No.	Setting	Description	UTMs (NAD 83, Zone 13)	
1	Plains	1 sardine can fragment	678657 Easting	3589818 Northing
2	Plains	1 quartzite hammerstone, >4 cm in size; 1 chalcedony cortical core-reduction flake, 2-4 cm in size, 10% cortex	678432 Easting	3589000 Northing
3	Plains	5 pieces of Ball jar fragments; 1 base fragment	678496 Easting	3589482 Northing

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IO No.	Setting	Description	UTMs (NAD 83, Zone 13)	
4	Plains	2 chalcedony non-cortical core-reduction flakes, 1-2 cm in size; 1 chalcedony cortical core-reduction flake, 1-2 cm in size, 10% cortex; 1 gray chert non-cortical core-reduction flake, 1-2 cm in size; 1 chalcedony angular debris, 2-4 cm in size; 1 pink chert cortical core-reduction flake, 2-4 cm in size, 5% cortex	679422 Easting	3588733 Northing
5	Plains	1 clear bottle (Figure 3)	678890 Easting	3589366 Northing
6	Plains	Metal can fragments	678518 Easting	3588493 Easting

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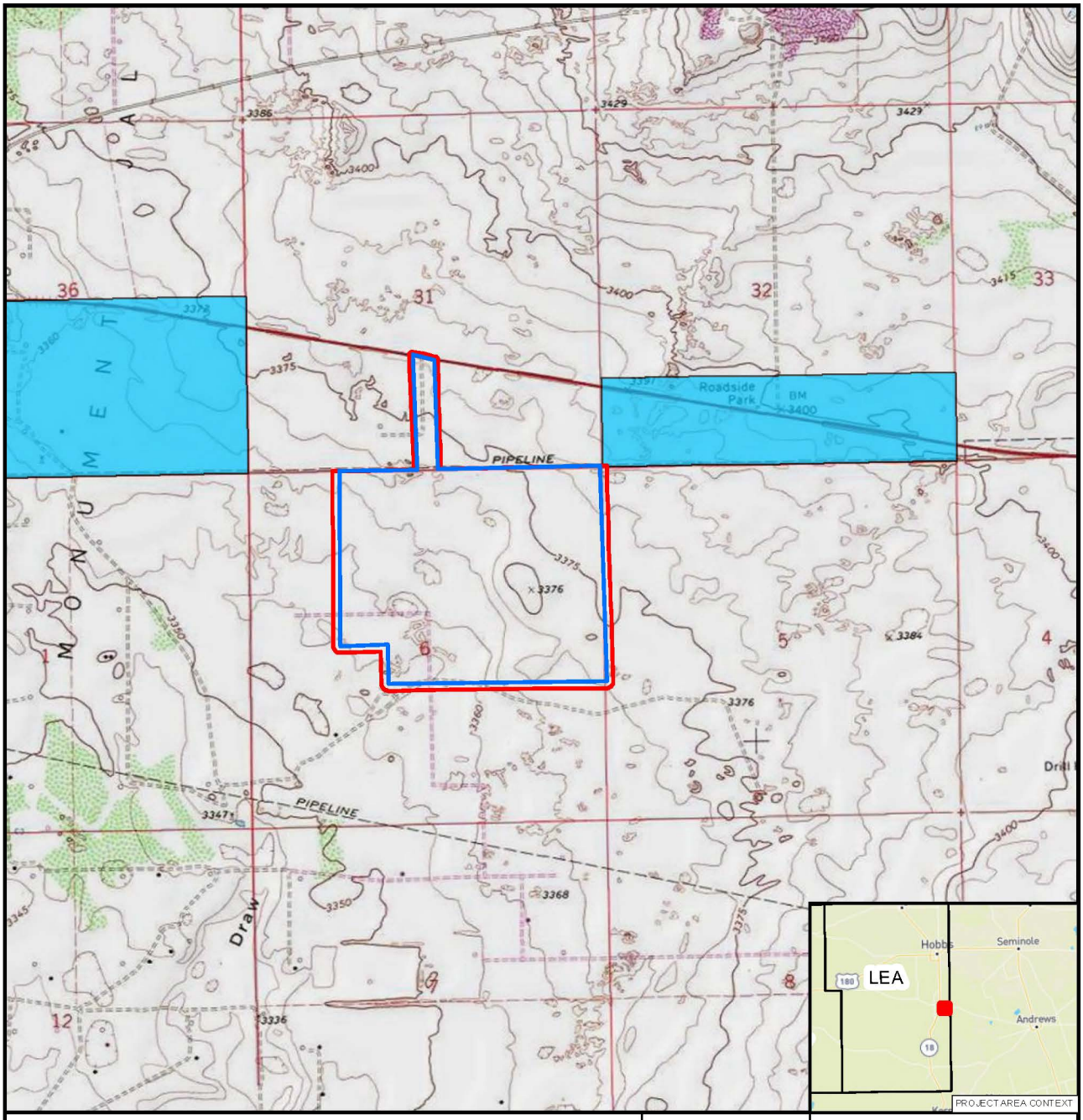

Legend

Project Area

Survey Area

Land Ownership

Private

State

0 0.25 0.5 1 Miles

0 0.5 1 2 Kilometers

N

1:24,000

NOTES:
Project Area: 291.18 acres
Survey Area: 319.56 acres
Eunice NE, NM
7.5' USGS Quadrangle;
T22S, R33E, Sec.06,
T21S, R38E, Sec.31,
Lea County, New Mexico

FIGURE 1

OVERVIEW MAP

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

PROJECT NO.:	444620-335000A.02
REVISED:	4/2/2020
DRAWN BY:	robert.mccall
CHECKED BY:	robert.mccall
FILE NAME:	Fig_1.MXD

Eden Facility
Eunice CR
Lea County, New Mexico

Figure 2 –Project Area, Facing North

Figure 3 –Bottle

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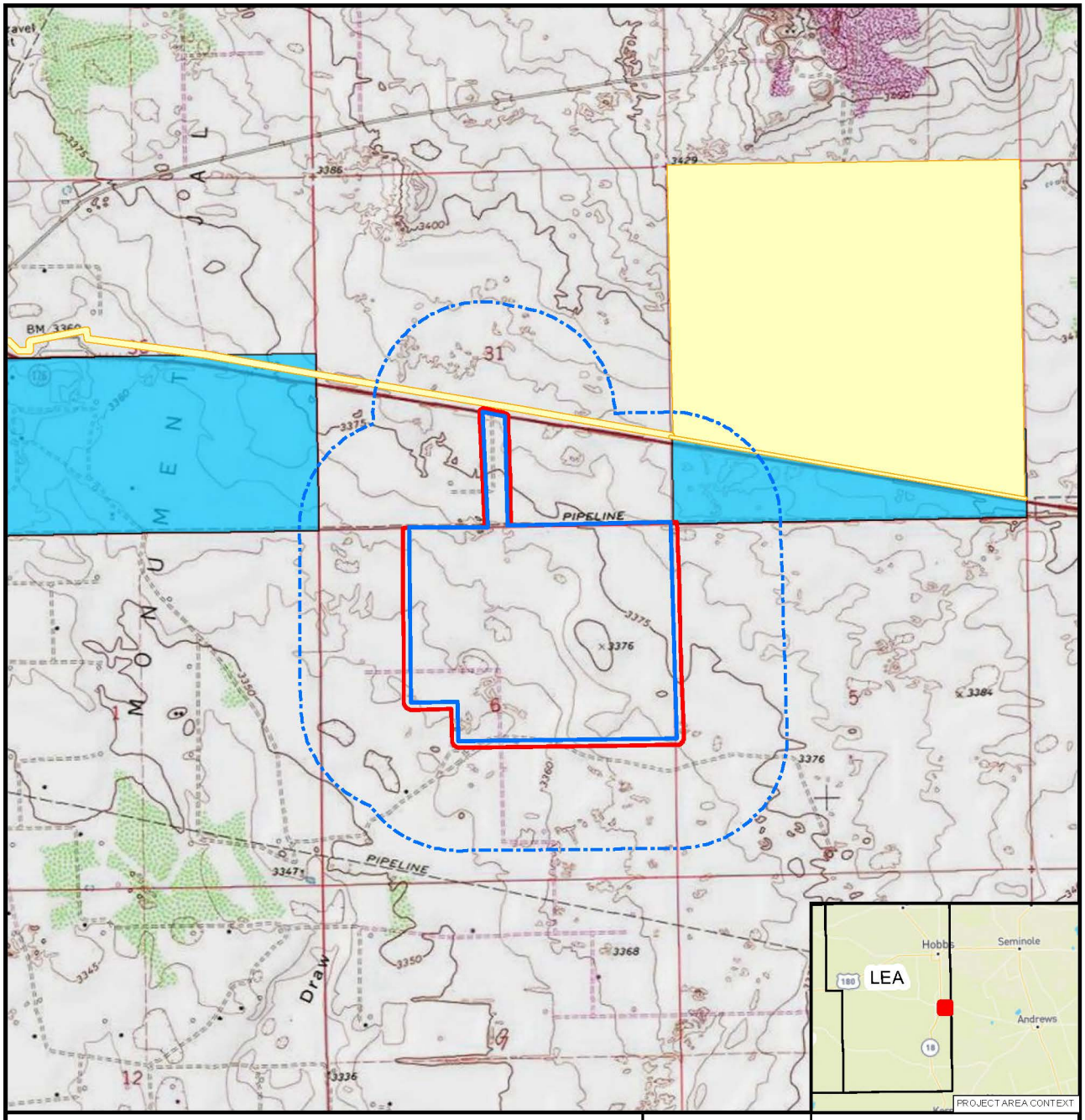
APPENDIX A:
CULTURAL RESOURCES LOCATION DATA

Confidential: The public disclosure of the location of archaeological sites is prohibited by Section 18-6-11.1 New Mexico Statutes Annotated 1978 and by 36 CFR 296.18.



Legend

- Project Area
- Survey Area
- 500m Arms Buffer
- Previously Surveys

Land Ownership

- Private
- State

0 0.25 0.5 1 Miles

0 0.5 1 2 Kilometers

N

1:24,000

NOTES:
Project Area: 291.18 acres
Survey Area: 319.56 acres
Eunice NE, NM
7.5' USGS Quadrangle;
T22S, R38E, Sec.06,
T21S, R38E, Sec.31,
Lea County, New Mexico

FIGURE A1

FILE SEARCH MAP

Service Layer Credits:
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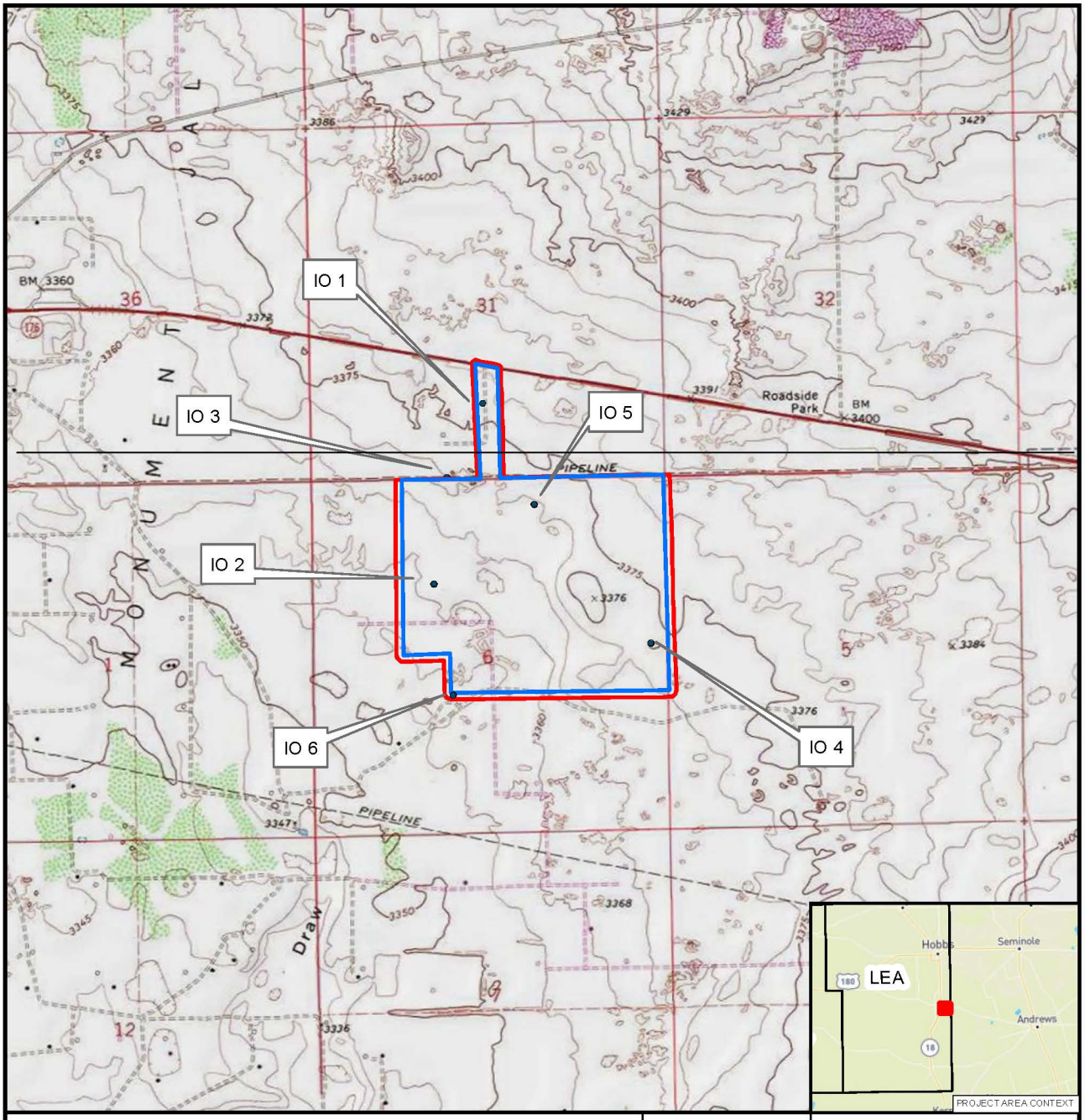
NV5

PROJECT NO.:	444620-335000A.02
REVISED:	4/2/2020
DRAWN BY:	robert.mccall
CHECKED BY:	robert.mccall
FILE NAME:	Fig_A1.MXD

Eden Facility
Eunice CR
Lea County, New Mexico



Legend

- Project Area
- Survey Area
- IO

NOTES:
Project Area: 291.18 acres
Survey Area: 319.56 acres
Eunice NE, NM
7.5' USGS Quadrangle;
T22S, R33E, Sec.06,
T21S, R38E, Sec.31,
Lea County, New Mexico

0 0.25 0.5 1 Miles
0 0.5 1 2 Kilometers
N
1:24,000

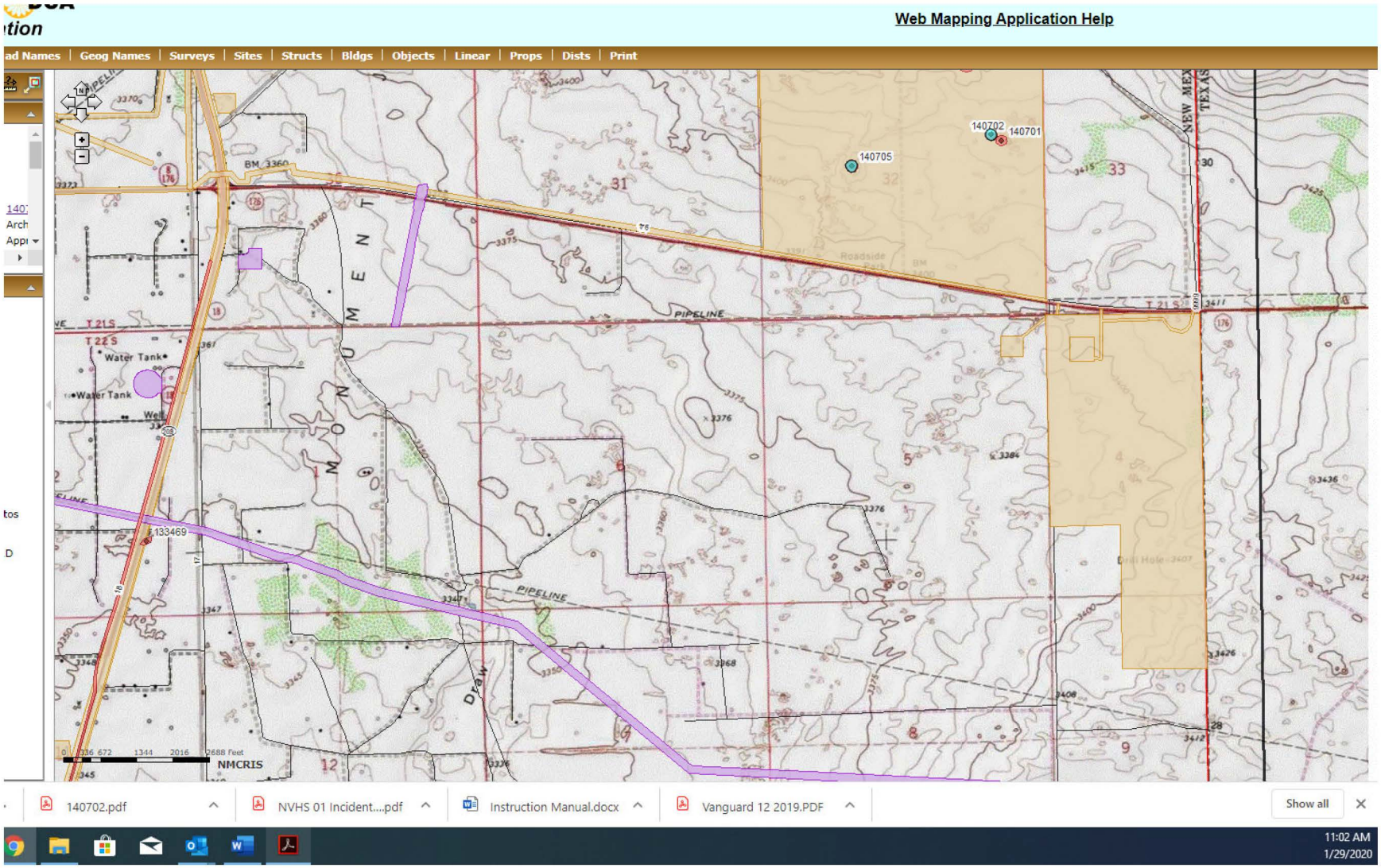
FIGURE A2

IO MAP

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

PROJECT NO.:	444620-335000A.02
REVISED:	4/2/2020
DRAWN BY:	robert.mccall
CHECKED BY:	robert.mccall
FILE NAME:	Fig_A2.MXD

Eden Facility
Eunice CR
Lea County, New Mexico



NMCRIS screenshot

ATTACHMENT TO APPENDIX 19B
QUALIFICATIONS OF SURVEY PERSONNEL

The following personnel performed the fieldwork during the Class III Inventory phase of this project: Joanne Eakin was the Principal Investigator; Toni Goar and Jack Lynn were Field Supervisors; and Josh Humiston was a Field Technician. Ms. Eakin also worked as a field technician to round out the survey crew.

From their respective resumes on file at NV5:

- Ms. Eakin (MA, Anthropology) is a Secretary of the Interior-qualified archaeologist with nearly 30 years of cultural resources management experience conducting cultural resource projects of all types pursuant to federal, state, and local laws and regulations, including Section 106 of the National Historic Preservation Act; the Archaeological Resource Protection Act (ARPA); the Native American Graves Protection and Repatriation Act (NAGPRA); and the National Environmental Policy Act (NEPA).
- Ms. Goar (MA, Historical Archaeology) has more than 27 years of experience in cultural resource management, mainly in New Mexico. She is responsible for overall project and budget management and oversees all staff within NV5's Cultural Resource Program in Albuquerque. She is also responsible for overseeing the analytical lab. She has completed numerous private and governmental assessments requiring NHPA Section 106 consultation. As a permitted New Mexico historian, Ms. Goar routinely completes archival research, and is the lead historical archaeologist for the office. She has conducted numerous surveys, archaeological excavations (testing and data recovery), cultural resource monitoring projects, public outreach projects, and completion of National Register of Historic Places (NRHP) nominations, mainly in the Southwest. Ms. Goar has written hundreds of reports, treatment plans, and final reports for data recovery. She has good working relationships with the land management and review agencies and holds the management agencies' permits as Principal Investigator and Field Supervisor for New Mexico and other states in the Southwest. She meets the Professional Qualifications of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (36 CFR 61, Appendix A).
- Mr. Lynn (MLitt, Battlefield and Conflict Archaeology) has been involved with the field of Cultural Resource Management and archaeology for nearly 10 years and has worked in 15 states as well as in the UK. His qualifications include extensive archaeological field experience in survey, testing and excavation working both as technical staff and in a supervisory role as well as lab work and report preparation. Mr. Lynn has also done occasional technical biological and geological fieldwork and environmental construction monitoring. Mr. Lynn's background includes service to public and private sector clientele, including NMDOT, the City of Deming, Kinder Morgan, and Xcel Energy.

Ms. Eakin, Ms. Goar, and Mr. Lynn were all certified as Supervisory Archaeologists per NMAC 4.18.8.13 A(2), "Supervisory Archaeologist." Ms Eakin, in addition, qualifies under NMAC 8.10.8.13 A(1), "Principal Investigator." All three also meet the Professional Qualifications of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (36 CFR 61, Appendix A). Each has a graduate degree in a relevant field of study (History, Archaeology, Anthropology, etc.) with at least two years of experience applying the theories, methods, and practices of those fields.