NORTHWEST MEDICAL ISOTOPES

Chapter 19.0 – Environmental Review

Construction Permit Application for Radioisotope Production Facility

NWMI-2013-021, Rev. 0A
June 2015

Prepared by:
Northwest Medical Isotopes, LLC
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FIGURES

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TERMS

Acronyms and Abbreviations

^{41}Ar	argon-41
^{7}Be	beryllium-7
^{14}C	carbon-14
^{137}Cs	cesium-137
^{131}I	iodine-131
^{132}I	iodine-132
^{40}K	potassium-40
^{98}Mo	molybdenum-98
^{99}Mo	molybdenum-99
^{100}Mo	molybdenum-100
^{63}Ni	nickel-63
^{112}Pd	palladium-112
^{106}Rh	rhodium-106
^{99}Tc	technetium-99
^{99m}Tc	technetium-99m
^{132}Te	tellurium-132
^{235}U	uranium-235
^{237}U	uranium-237
^{238}U	uranium-238
^{133}Xe	xenon-133
ABC Laboratories	Analytical Bio-Chemistry Laboratories, Inc.
A.D.	Anno Domini
ADUN	acid-deficient uranyl nitrate
AECL	Atomic Energy of Canada, Ltd
AEGL	Acute Exposure Guideline Level
ALARA	as low as reasonably achievable
ANSTO	Australian Nuclear Science and Technology Organization
B.C.	Before Christ
BLM	Bureau of Land Management
BMP	best management practice
BRR	BEA Research Reactor
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAM	continuous air monitor
CATSO	Columbia Area Transportation Study Organization
CDBG	Community Development Block Grant
CEQ	Council on Environmental Quality
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CNSC	Canadian Nuclear Safety Commission
CO	carbon monoxide
CO_2	carbon dioxide
COLT	Columbia Terminal
CSR	Code of State Regulations
CWA	Clean Water Act
DBA	design basis accident
DEQ	Division of Environmental Quality
Discovery Ridge	Discovery Ridge Research Park

DOA	Department of Administration
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EF scale	enhanced Fujita tornado intensity scale
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	environmental review
ERPG	Emergency Response Planning Guideline
F scale	(original) Fujita tornado intensity scale
FDA	U.S. Food and Drug Administration
FEMA	Federal Emergency Management Agency
FSAR	Final Safety Analysis Report
GCRA	Gans Creek Recreation Area
GHG	greenhouse gas
GIS	Geographical Information System
HAP	hazardous air pollutant
HEPA	high-efficiency particulate air
HEU	high-enriched uranium
HFR	High-Flux Reactor
HIC	high-integrity container
HVAC	heating, ventilation, and air conditioning
HWMC	Hazardous Waste Management Commission
ICP-MS	inductively coupled plasma mass spectrometry
IPaC	information, planning, and conservation
IRE	Institute of Radioelements
IRU	iodine retention unit
IX	ion exchange
Kr	krypton
LEU	low-enriched uranium
LLMW	low-level mixed waste
LLC	limited-liability company
LQG	large-quantity generator
LUST	leaking underground storage tank
Mallinckrodt	Mallinckrodt Pharmaceuticals, Inc.
MAR	material at risk
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MHA	maximum hypothetical accident
MHP	mobile home park
MIDUS	Medical Isotope Depleted Uranium Shielded
MMI	Modified Mercalli Intensity
MMRPC	Mid-Missouri Regional Planning Commission
MNRC	McClellan Nuclear Research Center
MoDOT	Missouri Department of Transportation
MOI	maximally exposed off-site individual
MU	University of Missouri
MURR	University of Missouri Research Reactor
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act

NESHAP	National Emission Standards for Hazardous Air Pollutants
NMSZ	New Madrid Seismic Zone
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRU	National Research Universal
NSR	new source review
NWMI	Northwest Medical Isotopes, LLC
O_3	ozone
OPAL	Open Pool Australian Lightwater
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSTR	Oregon State University TRIGA Reactor
OSU	Oregon State University
PAC	Protective Action Criteria
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCB	polychlorinated biphenyl
PCCE	private common collector elimination
PM	particulate matter
PM-2.5	particulate matter, 2.5 micron
PM-10	particulate matter, 10 micron
PPE	personal protective equipment
PSAR	preliminary safety analysis report
PTE	potential to emit
QA	quality assurance
RADIL	Research and Diagnostic Laboratory
RCRA	Resource Conservation and Recovery Act
ROI	region of influence
RPF	radioisotope production facility
RSAC	Radiological Safety Analysis Code
SAFARI-1	South African Fundamental Reactor Installation 1
SHPO	State Historic Preservation Office
SHWF	State hazardous waste facility
SLA	street light addition
SMART	Simple Multi-Attribute Rating Technique
SO_2	sulfur dioxide
SO_x	sulfur oxides
SPCC	spill prevention, control, and countermeasure
SRS	Savannah River Site
SVOA	semivolatile organic analyte
SWPPP	stormwater pollution prevention plan
TDD	Transportation Development District
TDS	total dissolved solid
TEEL	Temporary Emergency Exposure Limit
Terracon	Terracon Consultants, Inc.

TLD	thermoluminescent dosimeter
TMDL	total maximum daily load
TPH	total petroleum hydrocarbon
U	uranium
UC Davis	University of California at Davis
Union Carbide	Union Carbide Nuclear Corporation
UO_2	uranium dioxide
U.S.	United States
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VKM	vehicle kilometer traveled
VMT	vehicle miles traveled
VOA	volatile organic analyte
VOC	volatile organic compound
WCS	Waste Control Specialists
WNA	World Nuclear Association
WWTP	wastewater treatment plant
Xe	xenon

Units

°C	degrees Celsius
°F	degrees Fahrenheit
μ	micron
μg	microgram
μS	microsiemens
b	barn
Ci	curie
cm	centimeter
cm^2	cubic centimeters
dB	decibel
dBa	A-weighted decibel
ft	feet
ft^2	square feet
ft^3	cubic feet
g	gram
gal	gallon
ha	hectare
hr	hour
in.	inch
kg	kilogram
km	kilometer
km^2	square kilometers
kn	knots
kV	kilovolt
kW	kilowatt
L	liter
lb	pound
m	meter
m^2	square meter

m^3	cubic meter
mCi	millicurie
mEq	milliequivalent
mg	milligram
Mgal	million gallons
mi	mile
mi^2	square mile
min	minute
mL	milliliter
ML	million liters
mmho	millimho
mR	milliroentgen
mrem	millirem
mSv	millisievert
MT	metric ton
MW	megawatt
MWD	megawatt days
NTU	nephelometric turbidity unit
oz	ounce
pCi	picocurie
ppb	parts per billion
ppm	parts per million
sec	second
Sv	sievert
t	tonne (metric)
wt%	weight percent
yd^3	cubic yard
yr	year

19.0 ENVIRONMENTAL REVIEW

19.1 INTRODUCTION

Licensing Background

Northwest Medical Isotopes, LLC (NWMI) is applying to the U.S. Nuclear Regulatory Commission (NRC) to obtain a license for a production facility under Title 10, *Code of Federal Regulations* (CFR) Part 50 (10 CFR 50), "Domestic Licensing of Production and Utilization Facilities." Embedded in the 10 CFR 50-licensed facility will be several activities subject to 10 CFR 70, "Domestic Licensing of Special Nuclear Material," to receive, possess, use, and transfer special nuclear material and 10 CFR 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material," to process and transport molybdenum-99 (^{99}Mo) for medical applications.

NWMI intends to submit a single 10 CFR 50 license application for the radioisotope production facility (RPF) following the guidance in NUREG-1537, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors – Format and Content*, that encompasses activities regulated under different NRC requirements (e.g., 10 CFR 70 and 10 CFR 30), in accordance with 10 CFR 50.31, "Combining Applications," and 10 CFR 50.32, "Elimination of Repetition."

The NRC has determined that a radioisotope separation and processing facility, which also conducts separation of special nuclear material, will be considered a production facility and as such, will be subject to licensing under 10 CFR 50. A significant portion of the NWMI RPF is focused on the disassembly of irradiated low-enriched uranium (LEU) targets, separation and purification of fission product ^{99}Mo, and the recycle of LEU that is licensed under 10 CFR 50. The RPF will also include the fabrication of LEU targets, which will be licensed under 10 CFR 70. These targets will be shipped to NWMI's network of research or test reactors for irradiation (considered a connected action) and returned to the RPF for processing. The LEU used for the production of the LEU target materials will be obtained from the U.S. Department of Energy (DOE) and from LEU reclaimed from processing the irradiated targets.

NWMI's licensing approach for the RPF defines the following unit processes and areas that fall under the following NRC regulations:

- 10 CFR 50, "Domestic Licensing of Production and Utilization Facilities"
  - Irradiated LEU Target receipt (from network of university research or test reactors)
  - Irradiated LEU Target disassembly and dissolution
  - Mo recovery and purification
  - Uranium recovery and recycle
  - Waste management
  - Associated laboratory and support areas
- 10 CFR 70, "Domestic Licensing of Special Nuclear Material"
  - Receipt of fresh LEU (from DOE)
  - LEU target fabrication
  - Associated laboratory and support areas

Any byproduct materials produced or extracted in the RPF will be licensed under 10 CFR 30.

Introduction

In accordance with the provisions of 10 CFR 50 and supporting guidance, NWMI is providing this Applicant's Environmental Report – Construction Permit Stage (ER) in support of an application to construct and operate an RPF at Discovery Ridge Research Park (Discovery Ridge) in Columbia, Missouri. This ER is consistent with the content and organization of NRC-2011-0135, *Final Interim Staff Guidance Augmenting NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," Parts 1 and 2, for Licensing Radioisotope Production Facilities and Homogeneous Reactors* (NRC, 2012a), Chapter 19.

The ER supports the regulatory review that is performed by the NRC under 10 CFR 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Review," which requires that environmental impacts from the project be evaluated and described in a concise, clear, and analytical manner. This document also provides information for the NRC to conducts its environmental review in accordance with 10 CFR 51, Subpart A, "National Environmental Policy Act – Regulations Implementing Section 102 (2)."

This ER addresses the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 et seq.) actions needed to support activities that will be provisions incorporated in the requested 10 CFR 50 license, including certain activities regulated under 10 CFR 70 and 10 CFR 30.

An overview of the assessment of the environmental effects of construction, operation, and decommissioning of the RPF on the site and surrounding areas is provided in the ER. The document is structured as follows:

- **Section 19.1** presents the purpose and need of the proposed action, and the regulatory provisions, permits, and required consultations.
- **Section 19.2** presents the proposed action. This section includes the proposed site location and layout; facility description; process description; operations and systems descriptions; water consumption and treatment; cooling and heat dissipating systems; waste systems, storage, and treatment; and transport of the radioactive and nonradioactive materials, and the schedule associated with the major phases of the project.
- **Section 19.3** presents the affected environment. This section describes existing conditions at the site of the proposed action and serves as the baseline to measure changes in the affected environment caused by the proposed action. Resources applicable to the scope of the action are presented and include land use, visual resources, air quality, meteorology, noise, geologic environment, water resources, ecological resources, historical and cultural resources, socioeconomics, and human health.
- **Section 19.4** presents the direct, indirect, and cumulative effects/impacts to the resources described in Section 19.2.1.3 associated with construction, operations, and decommissioning of the proposed action. Data and analyses presented in this section are commensurate with the importance of the impact, with less important material summarized, consolidated, or referenced. This section also discusses postulated accidents and environmental justice.
- **Section 19.4.13** presents the alternatives and associated costs and benefits. This section discusses the costs and benefits of each alternative and the proposed action, including a qualitative discussion of environmental impacts.
- **Section 19.6** presents the conclusions, which address the unavoidable adverse environmental impacts of the proposed action, the relationship between short-term uses and long-term productivity of the environment, and irreversible and irretrievable commitments of resources used to support the proposed action.
- **Section 19.7** provides a list of references cited within this chapter.

19.1.1 Purpose and Need for Action

NWMI has formed a team of United States (U.S.) universities and companies to cost-effectively address the need for a domestic ^{99}Mo supply. NWMI intends to provide approximately 50 percent of the ^{99}Mo demand in North America and has developed an approach, including manufacturing and processing, using a "total LEU solution" to be implemented by 2017.

As set forth in Section 19.2.1, the proposed action is the issuance of an NRC license under 10 CFR 50, with provisions for 10 CFR 70 and 10 CFR 30 that would authorize NWMI to construct and operate the RPF for the production of ^{99}Mo at a site located in Columbia, Missouri. Proposed RPF activities include:

- Receiving LEU from DOE
- Producing LEU target materials and fabrication of targets
- Packaging and shipping LEU targets to the university reactor network for irradiation
- Returning irradiated LEU targets for dissolution, recovery, and purification of ^{99}Mo
- Recovering and recycling LEU to minimize radioactive, mixed, and hazardous waste generation
- Treating/packaging wastes generated by RPF process steps to enable transport to a disposal site

For purposes of complying with NEPA requirements, two or more university research reactors are assumed to obtain a license amendment authorized by the NRC to irradiate LEU targets. The ER includes an evaluation of irradiating LEU targets in a reactor. For a specific university research reactor to irradiate LEU targets, an amendment to the university's 10 CFR 50 NRC license and an analysis of site-specific environmental impacts related to such an amendment would be required.

Figure 19-1 illustrates the NWMI's general ^{99}Mo process and distribution flow.

Figure 19-1. General Molybdenum-99 Process Flow and Distribution

The NWMI process to manufacture ^{99}Mo is approved by the U.S. Food and Drug Administration (FDA). No direct approvals from the FDA to manufacture ^{99}Mo for commercial use at the RPF will be needed. However, each pharmaceutical distributer of Technetium-99m (^{99m}Tc) generators desiring to purchase ^{99}Mo from NWMI may need to seek FDA approval of NWMI as a manufacturer of the ^{99}Mo used in the manufacturer's ^{99m}Tc generators.

19.1.1.1 Background

^{99m}Tc is used for over 40 million nuclear medicine procedures annually. The characteristics of ^{99m}Tc allow high quality images with low radiation exposure to patients. ^{99m}Tc is very versatile for attaching to different chemical substances used to target different organs and diseases, as required by different diagnostic procedures. The two most widely used ^{99m}Tc-based procedures are for imaging blood flow to heart muscles (e.g., myocardial perfusion imaging) and mapping the spread of cancer to bones (e.g., skeletal metastases imaging).

The medical use of ^{99m}Tc has grown significantly since the early 1990s and is expected to have a moderate overall growth of 3–5 percent per year, with stronger growth in countries expanding healthcare programs (NAS, 2009).

Due to the short half-life of ^{99m}Tc of about 6 hours (hr), its parent isotope, ^{99}Mo, which has a 66-hr half-life, is the key supply chain product. ^{99}Mo is produced by bombarding uranium-235 (^{235}U) targets with neutrons from a nuclear reactor, with the resulting fission reaction producing ^{99}Mo and more than 250 other isotopes. After irradiation, targets are transferred to a processing facility and go through a number of extract and purification steps to produce ^{99}Mo. From the processing facility, the ^{99}Mo is shipped to radiopharmaceutical distributors (e.g., Lantheus Medical Imaging, Mallinckrodt Pharmaceuticals (Mallinckrodt), and GE Healthcare). The distributors then purify to FDA standards and package the ^{99}Mo in a radionuclide generator. This generator is called a ^{99m}Tc Generator Kit or "moly cow." The packaged kit is then shipped to nuclear pharmacies to be prepared for individual patient administration. Due to the short half-life, the ^{99}Mo must be efficiently processed and distributed.

The nuclear pharmacy uses the generator to facilitate the decay process from ^{99}Mo to ^{99m}Tc, extract the ^{99m}Tc doses, and bind the doses to compounds specific for an individual test needs. The ^{99m}Tc-compounded drug is then injected into the patient for various diagnostic-scanning purposes. This entire process usually takes place within six to nine days.

19.1.1.2 Molybedum-99 History

Beginning with the discovery of the ^{99m}Tc isotope by Emilio Segrè and Glenn Seaborg in 1938, the relationship between ^{99}Mo and ^{99m}Tc was clearly evident. As an observable fission product of ^{235}U in one of Segrè's later experiments, ^{99}Mo, having a half-life of about 66 hr, was observed emitting beta particles in its progression to a more stable state. In 1958, Walter Tucker and Margaret Green, two scientists under the direction of Powell Richards at the Brookhaven National Laboratory, hypothesized, based on their work with iodine-132 (^{132}I) and tellurium-132 (^{132}Te), that a "generator" could be developed using ^{99}Mo to produce ^{99m}Tc. In 1960, Richards became the first to suggest using ^{99m}Tc as a medical radionuclide tracer.

Benefitting from advancements in gamma camera technology, the production and medical use of ^{99m}Tc grew rapidly in the 1960s. Nuclear Consultants, Inc. and Union Carbide Nuclear Corporation (Union Carbide) began to manufacture commercial ^{99m}Tc generators. Mallinckrodt first undertook the production of ^{99}Mo using the research reactor at the University of Missouri Research Reactor (MURR); however, the size and flux capacity of the MURR reactor was insufficient to sustain a constant supply, and production of the isotope was stopped in the early 1980s. From 1968 to 1972, Union Carbide successfully developed a process using high-enriched uranium (HEU) targets at its Cintichem Facility in Tuxedo, New York, which permitted easy separation of the products of the fission process, thus, beginning domestic ^{99}Mo production in 1980.

Separating from Union Carbide, Cintichem Inc. became the sole producer of domestic ^{99}Mo during the 1980s. International production began in the same timeframe (e.g., Canada and Australia). A balance within the production-supply chain soon existed between the U.S., Canada, Netherlands, Belgium, and Australian production facilities, each having a share in the market and working collaboratively to help fill shortages created by a number of varying effects, including maintenance, inspection, and plant modifications.

In 1989, the Cintichem Facility had an underground leak of radioactive products that affected the surrounding environment. Due to this release, the surrounding community pressured the New York State government to have the Cintichem Facility cease production of ^{99}Mo. In May 1990, the Cintichem Facility closed and filed for decommissioning of its ^{99}Mo production facility, essentially shifting all production to Canada and Europe.

During the same timeframe, the use of ^{99m}Tc in diagnostic scanning continued to grow. In compliance with national regulatory agencies and the International Atomic Energy Agency recommendations, six reactor facilities sustain the HEU production supply:

- National Research Universal (NRU), Ontario, Canada
- High-Flux Reactor (HFR), Petten, Netherlands
- Belgian Reactor 2 (BR2), Mol, Belgium
- OSIRIS, near Paris, France
- MARIA, near Warsaw, Poland
- South African Fundamental Reactor Installation 1 (SAFARI-1), Pelindaba, South Africa

Two reactor facilities sustain the regional LEU production supply: Open Pool Australian Lightwater Reactor (OPAL, South Sydney, Australia) and RA-3 (Buenos Aires, Argentina). With a relatively constant supply and demand using all of the production facilities, the industry was able to produce the quantity of ^{99}Mo needed to fill generator orders from nuclear pharmacies all over the world. However, as these production facilities began to age, additional maintenance and facility improvements became inevitable, requiring temporary shutdowns for individual production facilities.

The first significant worldwide shortage came in November 2007, when the NRU reactor was shutdown for about month for routine maintenance. While the reactor was offline for repairs, the managing agency (Atomic Energy of Canada, Ltd [AECL]) decided to install an additional seismically qualified emergency power system for the two cooling pumps in the reactor, as required by the Canadian Nuclear Safety Commission (CNSC) operating license (amended in 2006). Instead of allowing for full inspections and testing of the new pumps, the Canadian House of Commons passed emergency legislation, without the consent of the CNSC, to restart NRU for commercial production with only one of the two seismic connections complete. With a 120-day grace period of operation issued by the Canadian House of Commons, NRU completed the second seismic connection in February 2008.

The most significant impact on ^{99}Mo production began in 2009, when the NRU reactor was shutdown during an unplanned shutdown of the HFR. In May 2009, a small heavy water leak was detected in the NRU reactor. While originally seen as a routine production stoppage, because of new regulations passed in January 2009, all operating reactors had to undergo intensive design reviews to comply with new safety standards to obtain a license renewal from the CNSC for commercial isotope production. Compliance with the new regulations consequently evolved from an anticipated 90-day renovation into a 17-month complete restructuring and redesign of the reactor and facility. With two-fifths of the world's ^{99}Mo supply facilities rendered inoperative for that period, production shifted to the Netherlands and other ^{99}Mo production sites.

As with the Canadian plant, the plant in the Netherlands faced renewal of its license in May 2010. With the supply of ^{99}Mo already depleted, the closing of the Dutch production plant placed a heavy strain on the worldwide production of ^{99}Mo. Nearly two-thirds of the production supply of ^{99}Mo for medical applications went offline for about six months. While the market did cope with the severe shortages by shifting production to other facilities and finding new ways to produce ^{99m}Tc through other isotope decay, the worldwide shortage exposed the large variability and fragility within the production process.

The National Research Council (NAS, 2009) documented the history of the development of the ^{99}Mo international isotope production industry and the U.S. role. This history is summarized in Figure 19-2. The report identified ^{99}Mo production before 2009.

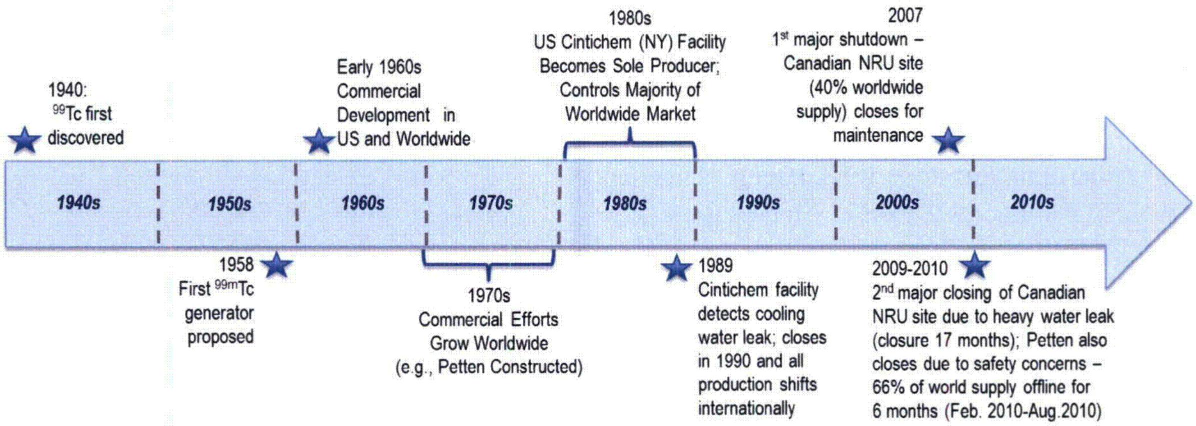


Figure 19-2. Historical Timeline of U.S. and Worldwide Molybdenum-99 Production Industry

19.1.1.3 Molybdenum Today

There are currently no domestic suppliers of ^{99}Mo. The U.S. supply chain structure includes six major reactors, four major processors, and two U.S. generator manufacturers. The irradiators, all using HEU targets, are spread across three continents and include: NRU in Canada (operating since 1957), owned by AECL; HFR in the Netherlands (operational since 1961), owned by the Institute of Energy of the Joint Research Center of the European Commission; OSIRIS owned by the French Atomic Energy Commission; BR-2 owned by the Belgian Nuclear Research Centre; MARIA owned by the Polish Institute of Atomic Energy; and SAFARI-1 owned by the Nuclear Energy Corporation of South Africa. Only the OPAL reactor in Australia, owned by Australian Nuclear Science and Technology Organization, and the RA-3 reactor in Argentina, owned by INVAP S.E., currently produce ^{99}Mo from LEU.

The HEU processors include Nordion Inc. in Canada, National Institute of Radioelements (IRE) in Belgium, Mallinckrodt (previously known as Covidien) in the Netherlands, and NTP Radioisotopes SOC Ltd, a subsidiary of the South African Nuclear Energy Corporation. The LEU processors include the Australian Nuclear Science and Technology Organization (ANSTO) and INVAP S.E. The current U.S. radiopharmaceutical distributors manufacture the ^{99m}Tc generator kits and distribute them to hospitals and clinics. ANSTO is the only LEU ^{99}Mo producer that provides ^{99}Mo in very small quantities to the U.S. through Lantheus Medical Imaging.

The entire reactor network is currently operating at or near capacity. Any unscheduled maintenance or other production disruption immediately translates into a supply disruption. Reliance on such a limited and aging resource results in an extremely delicate supply chain, the vulnerability of which was highlighted late in 2009 when an extended shutdown of the NRU reactor led to a critical ^{99}Mo shortage in North America, and the shutdown of the HFR reactor in August 2008 and November 2013 to the present has caused ^{99}Mo shortages in North America and Europe.

An estimated 40–50 kilograms (kg) (107–134 pounds [lb]) of HEU are used per year for the production of ^{99}Mo worldwide. In the past several years, nuclear non-proliferation and security concerns have led to increased worldwide pressure to mandate migration of HEU targets towards LEU targets by 2016. Conversion from HEU to LEU targets is both expensive and technically challenging for current producers of ^{99}Mo. This LEU mandate further exacerbates the risk of assured ^{99}Mo supply. Only the OPAL reactor in Australia currently produces ^{99}Mo from LEU. NWMI proposes to replace foreign HEU reactor irradiation with a domestic network of university reactors using LEU targets and a domestic processing facility for the extraction and purification of ^{99}Mo.

Figure 19-3 presents an overview of the worldwide nuclear reactors and radioisotope production facilities that currently produce ^{99}Mo.

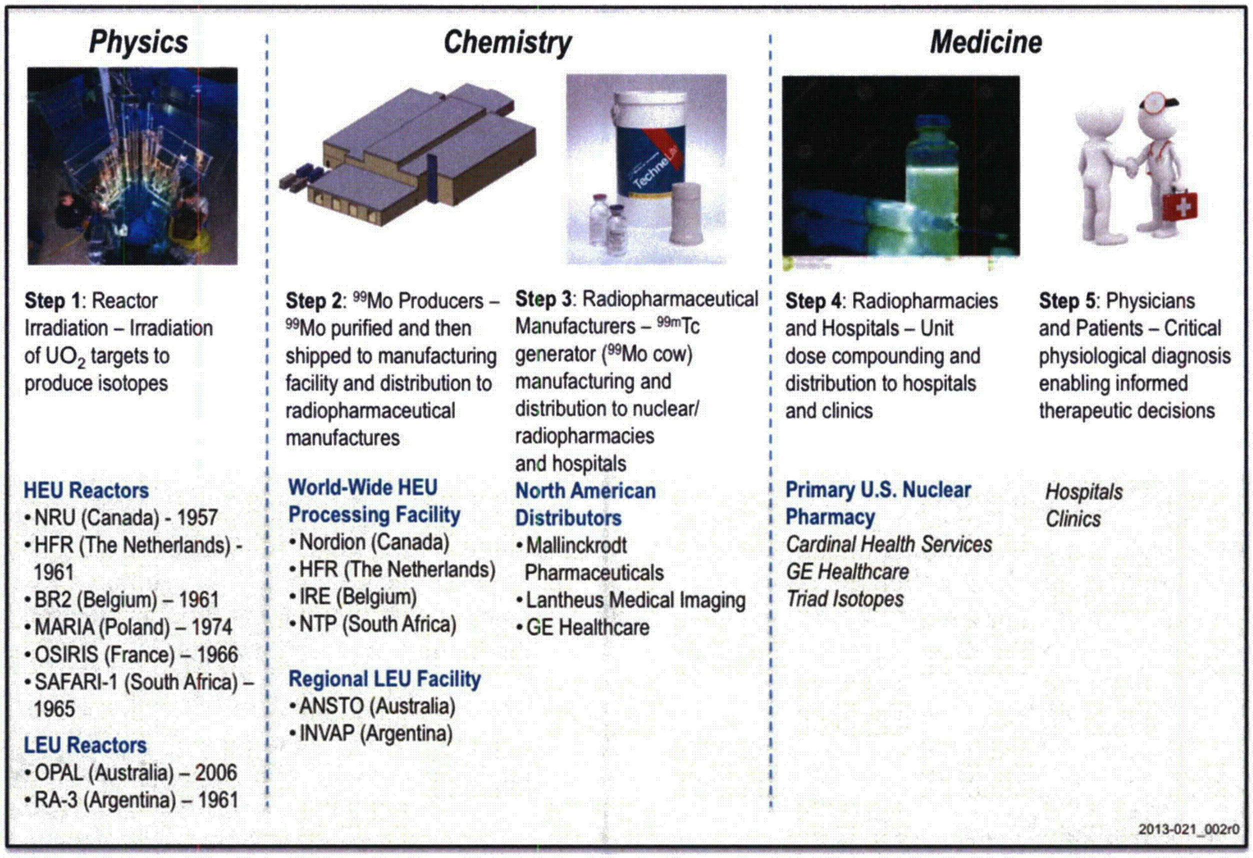


Figure 19-3. Overview of Current Molybdenum-99 Worldwide Process

19.1.2 Regulatory Provisions, Permits and Required Consultations

In addition to NRC licensing and regulatory requirements, a variety of Federal, State, and local environmental requirements apply to the RPF. Some require construction and operating permits or approvals, and others require facility compliance demonstrations. The following sections summarize the environmental requirements applicable to the RPF by the various regulatory agencies. Permits, approvals, and consultations necessary for RPF construction and operation are identified in Section 19.1.2.7 and Section 19.1.3.

19.1.2.1 U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) has primary authority for implementing the environmental requirements discussed in the following sections. The state of Missouri is delegated the authority to issue permits on behalf of EPA, and to administer and enforce many of the requirements applicable to the RPF, except for requirements under the Emergency Planning and Community Right-to-Know Act (EPCRA) (42 U.S.C. Chapter 116 § 11001–11050).

19.1.2.1.1 Clean Air Act

The Clean Air Act of 1970 (42 U.S.C. § 7401 et seq.) establishes regulations to ensure air quality and authorizes individual states to issue and manage air quality permits. The Act requires (1) National Ambient Air Quality Standards (NAAQS) to protect the public health, (2) national standards of performance for new or modified stationary sources of atmospheric pollutants, (3) evaluation of specific emission increases for prevention of significant deterioration in air quality, and (4) standards for the releases of hazardous air pollutants, including radionuclides. Implementing regulations include the following:

- 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards"
- 40 CFR 60, "Standards of Performance for New Stationary Sources"
- 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants" (NESHAP)
- 40 CFR 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories"

19.1.2.1.2 Clean Water Act

The Clean Water Act of 1972 (CWA) (33 U.S.C. § 1251 et seq.) requires states to set water quality standards for bodies of water within their boundaries, and directs EPA to regulate stormwater and wastewater discharges per the National Pollutant Discharge Elimination System (NPDES) permitting program. The EPA issues discharge permits under the requirements of 40 CFR 122, "EPA Administered Permit Programs: The National Pollutant Discharge Elimination System." The permit program controls water pollution by regulating point source discharges of pollutants into U.S. surface waters.

The NPDES construction stormwater program applies to sites with land disturbance of 0.4 hectares (ha) (1 acre) or more, including smaller sites in a larger common plan of development or sale. The NPDES industrial program applies to 10 categories of industrial activities conducted at facilities. Applicants may apply for either individual or a general NPDES permits. Individual permits are specifically tailored to the individual facility, and general permits cover multiple facilities with a specific category of discharges (e.g., stormwater discharges). NPDES permits specify the control technology applicable to each pollutant, the effluent limitations, and the deadline for compliance.

Wastewater generated from any facility or structure must be disposed through wastewater treatment and disposal systems. Facilities that discharge to a municipal or publically owned treatment works do not have NPDES permits but must meet pretreatment regulations. The pretreatment regulations require industrial users to obtain permits or authorizations and to use pollutant control mechanisms prior to discharging to the publically owned treatment works.

19.1.2.1.3 Safe Drinking Water Act

The Safe Drinking Water Act (42 U.S.C. § 300[f] et seq.) was enacted in 1974 to establish minimum national standards for public water supply systems. This Act authorizes EPA to set national standards for drinking water; provides guidance, assistance, and public information about drinking water; collects drinking water data; and oversees State drinking water programs. Primary and secondary drinking water regulations and regulations applicable to drinking water systems are identified in 40 CFR 141 and 142, "National Primary Drinking Water Regulations Implementation," and 40 CFR 143, "National Secondary Drinking Water Regulations." The EPA and states work together to ensure that these standards are met.

19.1.2.1.4 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act of 1976 (RCRA) (42 U.S.C. § 6901 et seq.) requires EPA to define and identify hazardous waste; establish standards for transportation, treatment, storage, and disposal; and require permits for persons engaged in hazardous waste activities. RCRA regulations are found in 40 CFR 260, "Hazardous Waste Management System: General," through 40 CFR 282, "Approved Underground Storage Tank Programs."

"Mixed waste" is hazardous waste containing radioactive material. This waste is regulated by RCRA and the Atomic Energy Act (42 U.S.C. § 2011 et seq.). In 40 CFR 266, "Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities," EPA conditionally exempts low-level mixed waste (LLMW) from the definition of hazardous waste in 40 CFR 261.3, "Definition of Hazardous Waste." The conditional exemption applies to (1) waste generated under a single NRC license that meets certain conditions for management, and (2) stored and treated tanks or containers meeting substantive RCRA requirements. LLMW that meets the applicable treatment standards in 40 CFR 268, "Land Disposal Restrictions," may also be exempt from RCRA transportation and disposal requirements.

19.1.2.1.5 Emergency Planning and Community Right-to-Know Act

The EPCRA establishes the requirements for Federal, State, and local governments; Indian Tribes; and industry regarding emergency planning and community right-to-know reporting on hazardous and toxic chemicals. The EPCRA is implemented by:

- 40 CFR 355, "Emergency Planning and Notification"
- 40 CFR 370, "Hazardous Chemical Reporting: Community Right-To-Know"
- 40 CFR 372, "Toxic Chemical Release Reporting: Community Right-To-Know"
- 40 CFR 373, "Reporting Hazardous Substance Activity When Selling or Transferring Federal Real Property"

EPCRA requires a submission of: (1) a list of hazardous chemicals present at the facility in excess of 10,000 lb for which material safety data sheets are required, (2) an Emergency and Hazardous Chemical Inventory Form (Tier II Form) identifying the inventory of hazardous chemicals present during the preceding year, and (3) notification to the State Emergency Response Commission and the local Emergency Planning Committee of any accidental releases of hazardous chemicals in excess of reportable quantities. The list of hazardous chemicals and the Tier II Form are submitted to regional fire departments. Facilities also must submit a toxic chemical release report to the EPA and the resident state if toxic chemicals are used at the facility in excess of established threshold amounts.

19.1.2.2 U.S. Department of Transportation

The Hazardous Materials Transportation Act of 1975 (49 U.S.C. §§ 5101–5127) regulates transportation of hazardous material in and between states. States may regulate the transportation of hazardous materials as long as the State requirements are consistent with the Act or U.S. Department of Transportation (DOT) regulations. DOT regulations of interest to this action include the following:

- 49 CFR 107, "Hazardous Materials Program Procedures," Subpart G, "Registration and fee to DOT as a person who offers or transports hazardous materials"
- 49 CFR 171, "General Information, Regulations, and Definitions"
- 49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements and Security Plans"

- 49 CFR 173, "Shippers – General Requirements for Shipments and Packages"
- 49 CFR 175, "Carriage by Aircraft"
- 49 CFR 177, "Carriage by Public Highway"

19.1.2.3 U.S. Army Corps of Engineers

Both the EPA and U.S. Army Corps of Engineers jointly administer Section 404 of the CWA, which requires permits for the discharge of dredged or fill material into waters of the U.S. The requirements for Section 404 permits are identified in 40 CFR Subpart 230.404(b)(1), "Guidelines for Specification of Disposal Sites for Dredged or Fill Material." States are responsible for issuing Section 401 certifications for NPDES and Section 404 permits that certify the permitted activity complies with all applicable State water quality standards, limitations, and restrictions.

19.1.2.4 Occupational Safety and Health Administration

The Occupational Safety and Health Act of 1970 (29 U.S.C. §§ 657–658) is designed to increase the safety of workers in the workplace. The Act stipulates that the U.S. Department of Labor is expected to recognize the dangers that may exist in workplaces and establishes employee safety and health standards. The Occupational Safety and Health Administration (OSHA) regulates mitigation requirements and mandates proper training and equipment for workers as established in 29 CFR 1910, "Occupational Safety and Health Standards."

19.1.2.5 Missouri State Agencies

Several programs responsible for protection and management of the environment and public health in Missouri are applicable to the proposed RPF. These programs are managed by the Missouri Department of Natural Resources (MDNR), the Department of Health and Senior Services, and the Department of Conservation.

The proposed facility site is located at the Discovery Ridge on property owned by the University of Missouri (MU) System headquartered in Columbia, Missouri. Discovery Ridge is being developed under the guidance of the *Discovery Ridge Master Plan and Protective Covenants* (MU, 2009). Consolidated Public Water Supply District #1 has extended drinking water services to the site and sewer lines. The Master Plan requires tenant compliance with the Discovery Ridge Master Storm Water Management Plan that is developed on a project-by-project basis and is based on regional accepted practices for stormwater management, including MDNR regulations (MDNR, 2012a). General environmental requirements and permits for new facilities are discussed in the following sections. Integration with the existing services or plans of Discovery Ridge is discussed, as applicable.

19.1.2.5.1 Missouri Department of Natural Resources

The Division of Environmental Quality (DEQ), within the MDNR, includes the Air Pollution Control Program, Water Protection Branch, Hazardous Waste Program, Public Drinking Water Branch, and State Historic Preservation Office. The following sections summarize these programs.

19.1.2.5.1.1 Air Pollution Control Program

The Air Conservation Commission administers the air quality standards and requirements within the Code of State Regulations (CSR), specifically 10 CSR Division 10, "Air Conservation Commission."

Construction permits – Construction permits are also called new source review permits and are issued by the Air Conservation Commission. Construction permits allow for construction and operation of an air emission source and are required prior to commencing construction of an air emission source. All new installations built with the potential to emit (PTE) a regulated air pollutant in an amount equal to or greater than the *de minimis* (threshold) level are required to obtain a construction permit.

A construction permit is not required if potential emissions of the entire installation are less than regulatory *de minimis* levels or potential emissions of the proposed project are below the insignificance levels. Permit exemptions are detailed in 10 CSR 10-6.061, "Construction Permit Exemptions."

The regulated air pollutants, *de minimis* emissions levels, and insignificance levels for determining exemptions and new source review thresholds are listed in Table 19-1 and Table 19-2.

Table 19-1. *De Minimis* Emission Levels of 10 CSR 10-6.020(3)(A)

Air contaminant	Emission rate (t/yr)	Emission rate (ton/yr)	Air contaminant	Emission rate (t/yr)	Emission rate (ton/yr)
Carbon monoxide (CO)	90.71	100	Asbestos	0.0064	0.007
Nitrogen dioxide (NO_2)	36.28	40	Fluorides	2.72	3
Particulate matter	22.67	25	Sulfur acid mist	6.35	7
Particulate matter, 10 micron (PM-10)	13.6	15	Vinyl chloride	0.91	1
Sulfur dioxide (SO_2)	36.28	40	Hydrogen sulfide	9.07	10
Ozone (to be measured as VOCs)	36.28	40	Total reduced sulfur (including hydrogen sulfide)	9.07	10
Lead	0.544	0.6	Reduced sulfur compounds (including hydrogen sulfide)	9.07	10
Mercury	0.090	0.1	Hazardous air pollutant (each)	9.07	10
Beryllium	0.00036	0.0004	Sum of hazardous air pollutants	22.67	25

Source: 10 CSR 10-6.020, "Definitions and Common Reference Tables," *Missouri Code of State Regulations*, as amended.

VOC = volatile organic compound.

Table 19-2. Emission Levels of Common Air Pollutants

Pollutant	Insignificant levels (kg/hr)	Insignificant levels (lb/hr)	Regulatory *de minimis* levels (t/yr)	Regulatory *de minimis* levels (ton/yr)	Major source thresholds – operating permits/NSR names sources (t/yr)	Major source thresholds – operating permits/NSR names sources (ton/yr)	Major source thresholds – NSR non-name sources (t/yr)	Major source thresholds – NSR non-name sources (ton/yr)
PM-10	0.45	1.00	13.6	15	90.7	100	226.8	250
SO_x	1.25	2.75	36.29	40	90.7	100	226.8	250
NO_x	1.25	2.75	36.29	40	90.7	100	226.8	250
VOC	1.25	2.75	36.29	40	90.7	100	226.8	250
CO	3.12	6.88	90.7	100	90.7	100	226.8	250
HAPs	[a]0.23	[a]0.5	9.07/22.67	10/25	9.07/22.67	10/25	226.8	10/25

[a] Or the hazardous emission threshold as established in Subsection (12)(J) of 10 CSR 10-6.060, "Construction Permits Required," whichever is less.

CO = carbon monoxide.
HAP = hazardous air pollutant.
NO_x = nitrogen oxides.
NSR = new source review.
PM-10 = particulate matter, 10 μ.
SO_x = sulfur oxides.
VOC = volatile organic compound.

The PTE of the RPF project will be calculated based on the maximum design capacity of the equipment, assuming continuous operation (24 hr/day, 365 days/year). In the Construction Permit Application, the RPF may request emission limits that, if accepted by the Missouri Air Pollution Control Program, will become part of the constraints in the construction permit. The proposed limits could change the type of RPF construction permit issued and the operating permit status.

Operating permits – Operating permits are issued by the Air Pollution Control Program in accordance with Title V of the 1990 Clean Air Act amendments and implementing regulations in 40 CFR 70, "State Operating Permit Programs." All sources with a PTE-regulated air pollutant above *de minimis* levels are required to obtain an operating permit. There are three classes of operating permits in Missouri:

- ***40 CFR 70 operating permit*** – This is required for installations with potential emissions exceeding 91.7 tonne per year (t/yr) (100 tons per year [tons/yr]) of any criteria pollutant, (9.07 t/yr) 10 tons/yr of any single hazardous air pollutant (HAP), or 22.7 t/yr (25 tons/yr) of combined HAPs; or if the EPA Administrator requires a 40 CFR 70 permit as part of a Federal rulemaking. These emissions levels are calculated after control devices and are called the major source threshold.
- ***Intermediate (or synthetic minor) operating permit*** – These permits may be obtained by installations with a PTE above the major source threshold that request a voluntary limit on operations to keep emissions below the major source threshold. Conditions could include absolute emissions limits, recordkeeping of operating hour limits, or production limits.
- ***Basic State operating permit*** – This permit is required if the PTE is between *de minimis* and major levels. All incinerators must obtain an operating permit, regardless of the level of emissions.

Sources of nonradioactive criteria air pollutants or HAPs from RPF construction may include fugitive dust and vehicle emissions (on-road and off-road vehicles). Vehicle emissions are also a source of greenhouse gases (GHG). Operation of the RPF may generate criteria air pollutants, HAPs, and GHGs from diesel-fired boilers, electric diesel generators, and facility chemical usage.

The NRC implements the primary radiation protection standards for RPF air emissions. Radioactive air emissions will be addressed in the license application and subject to the dose limits and requirements of 10 CFR 20, "Standards for Protection Against Radiation."

19.1.2.5.1.2 Water Protection Branch

The MDNR Clean Water Commission administers water quality standards and requirements in 10 CSR Division 20, "Clean Water Commission." The Clean Water Commission issues construction and operating permits as required in 10 CSR 20-6.010, "Construction and Operating Permits," to persons who build, erect, alter, replace, operate, use, or maintain existing point sources, or intend these actions for a proposed point source, water contaminant sources, or wastewater treatment facilities. These permits enforce the Missouri Clean Water Law and regulations and administer the NPDES program. Nonpoint source discharges and service connections to wastewater sewer systems are exempt from permitting requirements.

The proposed lot for the RPF at Discovery Ridge is approximately 3.0 ha (7.4 acres). An NPDES construction stormwater management permit is required for disturbances of greater than 0.4 ha (1 acre) of land. The RPF would either operate under a Missouri General Operating Permit MO-R10A000 for land disturbance on new sites or conform to the criteria and standards of the Discovery Ridge Master Storm Water Management Plan under a stormwater management permit issued to the site.

The Clean Water Commission issues a 401 Water Quality Certification to any facility requiring a Federal Section 404 (of the CWA) permit. This includes facilities that place material or fill into the jurisdictional waters of the U.S. The Section 401 certification is verification by the state of Missouri that the project would not violate water quality standards. The construction, operation, and decommissioning of the RPF is not anticipated to need a Federal Section 404 permit or Section 401 certification from the Commission.

Under 10 CSR 20-6.010, facilities that discharge wastes into a sewerage system are not required to obtain an NPDES permit if the owner of the sewerage system has a valid NPDES permit. The RPF would not discharge process wastewater into the Discovery Park sewer system. Sanitary wastewater would be discharged in accordance with Boone County sewer regulations.

19.1.2.5.1.3 Hazardous Waste Program

The Hazardous Waste Management Commission (HWMC) administers the hazardous waste standards and requirements in 10 CSR Division 25, "Hazardous Waste Management Commission."

The HWMC regulates hazardous waste and administers a permitting program for owners and operators of treatment, storage, and disposal facilities. 10 CSR Division 25 hazardous waste management rules incorporate by reference, unless otherwise modified, the Federal hazardous waste management regulations. The effective date for rules for mixed radioactive and hazardous wastes in Missouri was March 12, 1993.

Under 10 CSR 25-7.270, "Missouri Administered Permit Programs: The Hazardous Waste Permit Program," a permit is required for the treatment, storage (generated onsite and stored beyond the timeframes allowed without a permit pursuant to 10 CSR 25-5.262, "Standards Applicable to Generators of Hazardous Waste") or disposal of hazardous waste. Resource recovery of hazardous waste is regulated by 10 CSR 25-9.020, "Hazardous Waste Recovery Processes," and an owner or operator of a facility that uses, reuses, or recycles hazardous waste must be certified under 10 CSR 25-9, "Resource Recovery," or permitted under 10 CSR 25-7, "Rules Applicable to Owners/Operators of Hazardous Waste Facilities." A permit is not required for an elementary neutralization unit or a wastewater treatment unit that receives hazardous waste generated onsite and demonstrates compliance with the requirements of 10 CSR 25-7.270(2)(A)3 to the satisfaction of the HWMC.

The RPF would generate hazardous, universal, and mixed waste (hazardous waste containing radioactive material) from facility processes. The waste may exhibit hazardous characteristics (e.g., corrosivity or toxicity) and contain spent regulated solvents. Waste would generally be managed under requirements of 10 CSR 25-5.262 and 10 CSR 25-16.273, "Standards for Universal Waste Management." Treatment, including elementary neutralization or resource recovery of solvents, may occur without a permit, subject to certification and demonstrations required under 10 CSR 25-9 and 10 CSR 25-7.270(2)(A)(3).

LLMW generated by the RPF would be managed to meet the storage and treatment conditional exemption in 10 CSR 25-7.266, "Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities" (incorporating 40 CFR 266, Subpart N, "Conditional Exemption for Low-Level Mixed Waste Storage, Treatment, Transportation, and Disposal"). The RPF mixed waste would be exempt from the definition of hazardous waste in 10 CSR 25-3.260, "Definitions, Modifications to Incorporations, and Confidential Business Information," as the waste would be generated under a single NRC license, stored, and treated in a tank or container, and managed according to conditions that include the following:

- NWMI would notify MDNR, in writing and by certified delivery, to claim a conditional exemption for LLMW stored in the facility.

- LLMW would be stored and treated in tanks or containers in compliance with the license requirements that apply to the proper storage of LLMW (not including those requirements that relate solely to recordkeeping).
- LLMW would be stored and treated in tanks or containers in compliance with chemical compatibility requirements.
- Inventory of the stored conditionally exempt LLMW would be conducted at least annually and be inspected at least quarterly for compliance with 10 CSR 25-7.
- Facility personnel who manage stored conditionally exempt LLMW would be certified and trained in a manner to ensure that the conditionally exempt waste is safely managed; this includes training in chemical waste management and hazardous materials incident response that meets the personnel training standards.
- An emergency plan would be maintained and provided to all local agencies that may respond to a fire, explosion, or release of hazardous waste or hazardous constituents.

19.1.2.5.1.4 Public Drinking Water Branch

The Safe Drinking Water Commission administers the public drinking water standards and requirements in 10 CSR Division 60, "Safe Drinking Water Commission." The mission of the Public Drinking Water Program is to provide safe and adequate public drinking water supplies for residents of and transients in the state. Drinking water for the RPF would be provided through service connections in accordance with the Columbia Code of Ordinance requirements (City of Columbia, 2013a).

19.1.2.5.1.5 Department of Health and Senior Services

The Department of Health and Human Services administers a radiation control program under the requirements of 19 CSR 20-10, "Protection Against Ionizing Radiation." Exemptions to the regulations are identified in 19 CSR 20-10.020, "Exemptions from Requirements of this Chapter," and include use of radioactive sources licensed by the NRC to installations in Missouri. Radioactive sources, as applicable to the RPF, would be managed under requirements of the NRC license and excluded from Missouri regulation.

19.1.2.5.1.6 Department of Conservation

The Department of Conservation is charged with the protection and management of Missouri fish, forest, and wildlife resources. Conservation requirements are identified in 3 CSR Division 10, "Department of Conservation." The department maintains two references relating to the status of listed plants and animals in Missouri: *The Missouri Species and Communities of Conservation Concern Checklist* (State of Missouri, 2014), and Wildlife Code of Missouri (3 CSR 10-4.110, "General Prohibition; Applications," and 3 CSR 10-9.110[1][B], "General Prohibition; Applications"). The Conservation Concern Checklist is used mostly for planning and communication purposes.

All birds, fish, crayfish, mussels, amphibians, reptiles, mammals, or other forms of wildlife, including other invertebrates listed in the checklist, are protected by the Wildlife Code. Collection or harvest of these species during RPF construction, operation, or decommissioning would only be performed according to applicable permits as prescribed in Chapter 5 of the Wildlife Code.

19.1.2.6 Local Governments

The RPF would be located in Columbia, Missouri, in Boone County. The following sections summarize how local jurisdictions implement environmental requirements for land disturbances, stormwater management, sewer discharges, and drinking water connections.

19.1.2.6.1 Boone County

The Boone County Resource Management Department centralizes the engineering, planning, and inspection services provided by the county. County requirements address stormwater management, stream buffers, floodplain regulations, driveway location, road design, subdivision requirements, and building construction. Boone County requires a land disturbance permit prior to land-clearing activities equal to or greater than 0.4 ha (1 acre) or within close proximity to an environmentally sensitive area. If not covered under Discovery Ridge land disturbances permits, NWMI would request a land disturbance permit through the Resource Management Department. The department also offers an electronic stormwater pollution prevention plan (SWPPP) for land disturbance projects disturbing 0.4 ha (1 acre) or more. The SWPPP template would guide NWMI through the SWPPP development process to help ensure that the SWPPP addresses all the necessary elements stated in the Missouri State General Permit and Boone County regulations (Boone County, 2013a).

The Boone County Regional Sewer District provides wastewater management services to Discovery Ridge. The NWMI facility must comply with the applicable requirements of Chapter 2 of the Sanitary Sewer Use Regulations, including Section 2.12, "Unlawful Dischargers," establishing pollutant limits and pretreatment requirements, and Section 2.17.2, "Operating, Inspection, and Monitoring," which is for industrial users (Boone County, 2013b).

The Missouri State Legislature (Missouri Revised Statutes, Chapter 64.850, "County commission may prescribe zoning regulations") delegated the responsibility to local governmental units to adopt floodplain management regulations designed to protect health, safety, and general welfare. This ordinance applies to all lands within the jurisdiction of Boone County, identified as numbered and unnumbered A, AE, AO, and AH zones on Panel 29019CIND0A of the Flood Insurance Rate Map for Boone County (Boone County, 2011). A floodplain development permit must be acquired for all proposed construction or other development, including the placement of manufactured homes, in those zones. The RPF site is not located within any of these zones.

19.1.2.6.2 City of Columbia

Potable water connections – The Columbia Water Treatment Plant is owned and operated by the City of Columbia and the Water and Light Department. The system supplies water to approximately 45,500 customers. The water system has approximately 46,250 service connections, and the average daily consumption is 47.69 million liters (ML)/day (12.6 million gallons per day ([Mgal/day]). The Columbia Water Treatment Plant is in compliance with all State and Federal drinking water regulations. The plant is in the Northeast Regional Office district of the MDNR. Requests for drinking water connections would be made in accordance with Code of Ordinances, Chapter 27, "Utilities for the City of Columbia" (City of Columbia, 2013a). Code of Ordinances, Chapter 6, "Buildings and Building Regulations" (City of Columbia, 2013b), adopts the 2009 Edition of the International Building Code (IBC, 2009) by reference with amendment, and would be the building standard for the RPF.

Stormwater regulation – The City of Columbia and Boone County adopted stormwater regulations in response to requirements mandated by EPA as part of implementing Phase II of the CWA (MDNR, 2012a). These regulations were adopted by the city in 2007 and the county in 2010. Two components are within each set of regulations: Stormwater Management Standards, and Stream Buffer Standards.

Stormwater management – The adopted city and county regulations address the water quantity and water quantity that leaves a development site. The regulations specify that the volume of post-development runoff cannot exceed that of a site's predevelopment state. Therefore, many new developments require significant on-site detention and filtration facilities. Previous regulations allowed stormwater to be discharged directly into the creeks (MDNR, 2012a). Under the city stormwater regulations, subdivisions preliminarily platted prior to September 2007 are exempt from the new regulations (City of Columbia, 2013a).

The goal of the new city regulations is to mitigate flooding, erosion, pollution of streams, and personal property damage caused by development activities.

Stream buffers – A major component of the City of Columbia and Boone County stormwater regulations is the stream buffering requirement. Stream buffers are natural vegetation areas that serve as boundaries between disturbed land and local waterways. The buffers act as filtration systems for stormwater runoff entering creeks and protect aquatic habitat. Stream buffers also stabilize stream banks, mitigate flooding, and preserve natural areas that serve as vital habitat and corridors. Stream buffers are measured from the ordinary high-water mark and vary in width depending on stream type. The three regulated stream types identified in the city and county regulations are shown in Table 19-3.

Table 19-3. Required Stream Buffer Width, Identified by Stream Type

Stream type	Description	Total buffer width, each side (m)	Total buffer width, each side (ft)
1	Perennial	31	100
2	Intermittent	15.2	50
3	Ephemeral	9.2	30

Stream buffers were expanded to include slopes greater than 15 percent that are adjacent to outer buffers. City and county regulations include a 61 meter (m) (200-foot [ft]) buffer from karst features (e.g., sinkholes). The inner half of stream buffers must be left as undisturbed natural vegetation. In Columbia, but not in Boone County, accessory structures (e.g., sheds) may be built within the outer half of these buffers. Trails and maintained lawns may be situated within the outer buffer.

Landscaping regulations – Landscaping and screening standards exist as part of the city zoning ordinance. These provisions are intended to accomplish the following:

- Establish healthy environmental conditions by providing shade, air purification, oxygen regeneration, groundwater recharge, stormwater runoff retardation, erosion control, and noise, glare, and heat abatement
- Provide visual buffering from streets, to buffer potentially incompatible land uses and to generally enhance the quality and appearance of a development site
- Encourage the preservation of existing trees and vegetation
- Supplement the land disturbance permit requirements

The landscaping standards apply to all new development and new parking lots exceeding a minimum threshold size. There are several exclusions to the landscaping requirements, which are explained in the zoning ordinance (City of Columbia, 1998).

Tree preservation regulations – While City of Columbia requires tree preservation, Boone County has no specific tree preservation ordinance. However, with the recent adoption of the county stream buffer regulations, there exists an opportunity to implement the first ongoing regulation that would have a direct effect on tree preservation.

According to the MDNR, tree preservation has been most effective on unsubdivided parcels greater than 0.4 ha (1 acre) inside the city limits. This is the result of the city requirement that a tree survey be conducted to determine what climax forest exists on a site prior to land-clearing activities.

19.1.2.7 Permit and Approval Status

A final determination of permits and approvals applicable to the RPF would be made with appropriate regulatory interface. Consultations will ensure that applications or certifications are prepared and submitted in accordance with requirements, and approved in a timely manner. Permits and approvals necessary for RPF construction and operation are identified in Table 19-4.

Table 19-4. Regulatory Compliance Status (4 pages)

Agency	[a]Regulatory authority	Permit or approval	Activity covered	Status
	Federal			
U.S Nuclear Regulatory Commission	Atomic Energy Act 10 CFR 50.50	Construction Permit	RPF construction	Addressed in Construction Permit Application
	10 CFR 50.57	Operating License	RPF operation	To be addressed in operation license application
	10 CFR 30	By-Product Material License	Production, possession, and transfer of radioactive by-product material	To be addressed in license application
	10 CFR 70	Special Nuclear Materials License	Receipt, possession, use, and transfer of special nuclear material	To be addressed in license application
	National Environmental Policy Act 10 CFR 51	Environmental assessment or environmental impact statement	Site approval for RPF construction and operation	Addressed in this Construction Permit Application
U.S. Army Corp of Engineers	Clean Water Act 33 CFR 323	Dredge and Fill Permit (Section 404)	Discharges of dredged or fill material into U.S. waters	Not required
U.S. Environmental Protection Agency	Resource Conservation and Recovery Act 40 CFR 262	Notification of RCRA Subtitle C activity	EPA identification number for generation of hazardous waste	Notification to be submitted 60 days prior to construction
	Clean Water Act 40 CFR 112, Subpart D, Appendix F	[b]SPCC plans for construction and operation	Storage of oil during construction and operation	SPCC plans to be submitted 30 days prior to construction
U.S. Department of Transportation	Hazardous Materials Transportation Act 49 CFR 107	Certificate of Registration	Transport of hazardous materials	Registration to be filed no later than June 30 of the calendar year or prior to offering hazardous materials for transport

Table 19-4. Regulatory Compliance Status (4 pages)

Agency	[a]Regulatory authority	Permit or approval	Activity covered	Status
State				
Missouri Department of Natural Resources	Federal Clean Air Act Missouri Revised Statute Chapter 643 10 CSR Division 10	Construction Permit	Construction of an air emissions source	Not required
		Part 70 Operating Permit	Operation of an air pollution emission source that has potential emissions exceeding 100 tons/yr of criterion pollutants	Not required
		Intermediate Operating Permit	Operation of an air pollution emission source that has the potential to emit is above major threshold, but a voluntary limits of operation is requested	Not required
		Basic State Operating Permit	Operation of an air pollution emission source that has the potential to emit is between *de minimis* and major levels	Not required
	Clean Water Act Missouri Revised Statute Chapters 640 and 644 10 CSR Division 20	NPDES Construction Stormwater Permit	Land disturbance and discharge of stormwater from the construction site	Applications for general permits (Forms E and G) to be submitted 30 days prior to construction
		NPDES Industrial Stormwater Permit	Discharge of stormwater from the industrial site during operations	Permit to be submitted one year prior to operation
		Section 401 Water Quality Certification	Certifies that the Section 404 permitted activity complies with all applicable State water quality standards, limitations, and restrictions	Not required

Table 19-4. Regulatory Compliance Status (4 pages)

Agency	[a]Regulatory authority	Permit or approval	Activity covered	Status
Missouri Department of Natural Resources (continued)	Resource Conservation and Recovery Act Missouri Revised Statute Chapter 260 10 CSR Division 25	Notification of Regulated Activity	Obtain Missouri identification number for generation of hazardous waste	Registration to be filed 90 days prior to generating hazardous waste
		Certified Resource Recovery Facility Application	Reuse, reclamation, or recycling 1,000 kg (2,204.6 lb) or more of site-generated hazardous waste in a month	Application to be submitted 90 days prior to operations
		Notification to MDNR of Conditional Exemption	Notify MDNR in writing and by certified delivery of the claim of a conditional exemption for LLMW stored and treated in the facility	Notification to be submitted 90 days prior to operations
		Hazardous Waste Permit	Treatment, storage or disposal of hazardous waste	Not required
Missouri Department of Health and Senior Services	Atomic Energy Act Missouri Revised Statute Chapter 192 19 CSR Division 20	Registration of sources of ionizing radiation	Protection against ionizing radiation	Radioactive sources will be managed under the NRC license and are excluded from Missouri regulation
Boone County				
Boone County Resource Management Department	Clean Water Act Missouri Revised Statute, Chapter 64 Boone County Stormwater Ordinance	Stormwater Discharge Permit	Stormwater management	Application to be submitted 30 days prior to construction
		Land Disturbance Permit	Activity disturbing 0.4 ha (1 acre) or more of land or disturbing 278.7 m^2 (3,000 ft^2) in environmentally sensitive areas	Application to be submitted 30 days prior to construction
	Missouri Revised Statute, Chapter 64 Boone County Zoning Regulations	Application for Commercial Building Permit	Construction of a commercial building	Application to be submitted 30 days prior to construction
Boone County Regional Sewer District	Clean Water Act Missouri Revised Statute Chapter 250 Chapter 2 of Boone County Sanitary Sewer Use Regulations	Sanitary sewer connection approval	Building connection to District wastewater treatment works	Required information to be submitted 30 days prior to construction

Table 19-4. Regulatory Compliance Status (4 pages)

Agency	[a]Regulatory authority	Permit or approval	Activity covered	Status
City of Columbia				
City of Columbia	Clean Water Act 10 CSR Division 60 Part II City of Columbia Code of Ordinances Chapter 27	Application for utility service	Allows RPF to connect to Columbia Water Treatment Plant	Application to be submitted 30 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 6, Article II	Building Permit	Approval of building code and standards, including site plan	Application to be submitted 60 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 6, Article III	Electrical plan approval	Electrical Code	Information to be submitted 60 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 6, Article IV	Plumbing plan approval	Plumbing Code	Information to be submitted 60 days prior to construction
	Part II Code of Ordinances Chapter 6, Article V	HVAC plan approval	Mechanical Code	Information to be submitted 60 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 6	Certificate of Occupancy	Facilities meeting Building Code	Information to be submitted upon completion of construction
	Part II City of Columbia Code of Ordinances Chapter 27, Article II	Fire Prevention Plan Approval	Fire Code	Information to be submitted 60 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 12A, Article II	Land Disturbances Permit	Land disturbance activity, including construction on any site that results in a disturbed area of 1 acre or more.	Application to be submitted 30 days prior to construction
	Part II City of Columbia Code of Ordinances Chapter 12A, Article V	Stormwater Management Plan Approval	Approval required prior to approval for Land Disturbance Permit	Information to be submitted 45 days prior to construction

[a] Full references are provided in Section 19.7.

[b] Only required when oil is stored in a tank or shell with a capacity over 1,320 gallons (gal), and the oil could reasonably reach navigable water.

CFR = Code of Federal Regulations.
CSR = Code of State Regulations.
EPA = U.S. Environmental Protection Agency.
HVAC = heating, ventilation, and air conditioning.
LLMW = low-level mixed waste.
MDNR = Missouri Department of Natural Resources.
NPDES = National Pollutant Discharge Elimination System.
NRC = U.S. Nuclear Regulatory Commission.
RCRA = Resource Conservation and Recovery Act.
RPF = radioisotope production facility.
SPCC = spill prevention, control, and countermeasure.
U.S. = United States.

19.1.3 Consultation and Coordination

Table 19-5 lists the consultations required for construction and operation of the proposed RPF. The table provides the following information for each consultation, as applicable, including the name of the responsible regulatory agency; applicable law, ordinance, or regulation; required consultation; summary of any surveys required to complete the consultation; and status.

Table 19-5. Consultation Required for Construction and Operation Status (2 pages)

Agency	[a]Regulatory authority	Required consultation	Surveys required	[b]Status
Federal				
USFWS	Endangered Species Act (16 U.S.C. § 1531 et seq.)	Consultation regarding potential to adversely impact protected species; concurrence with no appropriate mitigation measures	None	Consultation letter was submitted to the USFWS on July 14, 2014. Received response July 21, 2014 requesting that an IPaC form be prepared. Based on the analysis, the project area was determined to not include any designated critical habitat or suitable habitat for candidate or proposed species. No further action was required.
State of Missouri				
Missouri State Historic Preservation Office	National Historic Preservation Act (16 U.S.C. § 470 et seq., Section 106)	Consultation regarding potential to adversely impact historic resources; concurrence with no appropriate mitigation measures		Letter submitting the Cultural Resources Investigation to the Missouri State Historic Preservation Office, October 7, 2013. A response was received October 10, 2013; no additional action is required (Appendix B).
Missouri Department of Conservation	Rules of Department of Conservation (3 CSR 10)	None	None	Consultation letter was submitted to the MDC on July 14, 2014. No response has been received.
Native American Tribes				
Osage Nation	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act (25 U.S.C. § 3001 et seq.)	Consultation regarding protection of traditional Native American religious and cultural resources	None	Consultation letter was submitted to the Osage Nation on July 14, 2014. No response has been received.

Table 19-5. Consultation Required for Construction and Operation Status (2 pages)

Agency	[a]Regulatory authority	Required consultation	Surveys required	[b]Status
Iowa Tribe of Oklahoma	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources	None	Consultation letter was submitted to the Iowa Tribe of Oklahoma on July 14, 2014. No response has been received.
Kaw Nation	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources	None	Consultation letter was submitted to the Kaw Nation on July 14, 2014. No response has been received.
Miami Tribe of Oklahoma	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources	None	Consultation letter was submitted to the Miami Tribe of Oklahoma on July 14, 2014. No response has been received.
Omaha Tribe	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources	None	Consultation letter was submitted to the Omaha Tribe on July 14, 2014. No response has been received.
Yankton Sioux Tribe of South Dakota	• National Environmental Policy Act • National Historic Preservation Act • Native American Graves Protection and Repatriation Act	Consultation regarding protection of traditional Native American religious and cultural resources.	None	Consultation letter was submitted to the Yankton Sioux Tribe of South Dakota on July 14, 2014. No response has been received.

[a] Full references are provided in Section 19.7.

[b] Unless noted otherwise, copies of the consultation letters submitted/received are provided in Appendix A.

CSR = Code of State Regulations.
IPaC = information, planning, and conservation.
MDC = Missouri Department of Conservation.
U.S.C. = United States Code.
USFWS = U.S. Fish and Wildlife Service.

19.2 PROPOSED ACTION

As described in Section 19.2.1, the proposed action requires authorization by the NRC for NWMI to construct and later operate the proposed RPF at Discovery Ridge to commercially produce ^{99}Mo using LEU. Section 19.2.1 also describes actions that are connected to the proposed action. Connected actions fall within the scope of the actions evaluated in an environmental impact statement (40 CFR 1508.25, "Scope").

19.2.1 Description of Proposed Action and Connected Actions

The proposed action is the issuance of an NRC Construction Permit and Operating License under 10 CFR 50 and provisions of 10 CFR 70 and 10 CFR 30 that would authorize NWMI to construct and operate a ^{99}Mo RPF at a site located in Columbia, Missouri. Proposed RPF activities include:

- Receiving LEU from DOE
- Producing LEU target materials and fabrication of targets
- Packaging and shipping LEU targets to the university reactor network for irradiation
- Returning irradiated LEU targets for dissolution, recovery, and purification of ^{99}Mo
- Recovering and recycling LEU to minimize radioactive, mixed, and hazardous waste generation
- Treating/packaging wastes generated by RPF process steps to enable transport to a disposal site

The RPF is being designed to have a nominal operational processing capability of one batch per week of up to 12 targets from MURR for up to 52 weeks per year and approximately 30 targets from the Oregon State University (OSU) TRIGA[1] Reactor (OSTR) or a third university reactor for eight weeks per year per reactor. The impacts analyzed for this ER were based on the bounding scenario of MURR operating 52 weeks per year, with both the OSTR and third reactor operating eight weeks per year, for a total of 68 batches of irradiated LEU targets processed at the RPF annually.

For the proposed RPF to fulfill its function, other "connected actions" would also occur. The RPF connected action is the use of a network of university research reactors for the irradiation of LEU targets. The ER evaluates transport of the unirradiated LEU targets to each university research reactor, irradiation of the LEU targets at each reactor, and transport of the irradiated LEU targets back to the RPF. License amendments associated with university research reactors irradiating LEU targets would be completed by each reactor organization and would be separate from this proposed action.

NWMI has currently identified two university research reactors to be part of the irradiation network: MURR and OSTR.reactor will be added to the network that is similar to OSTR. An analysis to recommend the third university reactor is currently underway. The university reactors being considered include [Proprietary Information]. NWMI has bounded the decision for the third reactor by the university reactor that is the [Proprietary Information].

The primary activities to be completed during construction, pre-operation, operation, and decommissioning are described below.

Construction – During the construction phase of the RPF, the following types of construction activities would be completed, including land clearing, set up of equipment laydown areas, utility installation, buildings, parking lots, and roads.

Pre-Operations – Prior to commercial operations, the RPF would go through a commissioning phase to ensure that the facility functions as designed and meets all NRC license and State and local requirements. The commissioning process comprises the integrated application of a set of engineering techniques and procedures to check, inspect, and test every operational component of the project, from individual functions (e.g., instruments and equipment), to complex modules, subsystems, and systems.

[1] TRIGA (Training, Research, Isotopes, General Atomics) is a registered trademark of General Atomics, San Diego, California.

Operations – The RPF would have the operations capacity to produce 50 percent of the U.S. ^{99}Mo demand. ^{99}Mo produced from the proposed NWMI RPF would indistinguishable from ^{99}Mo from the existing fleet of nuclear reactors and would not require redesign of the ^{99}Mo generator technology in the U.S. supply chain.

Decommissioning – The process of closing and securing a nuclear facility would provide adequate protection from radiation exposure and to isolate radioactive contamination from the environment. Activities include surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the life of a facility to retire it from service, with adequate regard for the health and safety of workers and the public and protection of the environment.

19.2.1.1 Schedule

The schedule for proposed RPF construction, operation, and decommissioning is as follows:

- Start date of site preparation/construction: First quarter 2016
- End date of construction: First quarter 2017
- Start date of facility startup and cold commissioning (pre-operational): Second quarter 2017
- Date of hot commissioning and commercial operations: Third quarter 2017
- Date of decommissioning: 2047

19.2.1.2 Affected Land

During construction the total affected land would 3.0 ha (7.4 acres) or 100 percent of the site. The entire site (3.0 ha [7.4 acres]) would be permanently affected as a result of operational activities.

19.2.1.3 Personnel, Materials, and Equipment Required During Project Phases

All work completed prior to receiving the Construction Permit Application for the proposed RPF would be completed in accordance with 10 CFR 50.10(a)(2), "License Required; Limited Work Authorization." Table 19-6 provides an estimate of the resources required during each of the major facility phases (construction, pre-operation, operation, and decommissioning) of the proposed action.

Table 19-6. Resources Required During Radioisotope Production Facility Phases

Resource	Construction	Pre-operation	Operation	Decommissioning
Average workforce	38	21	98	15
Peak workforce	82	98	98	28
Delivery trucks (per week)	20	2	4	1
Offsite radioactive materials and waste shipments (per week)	1	0.5	10	20
Fuel (diesel), L/month (gal/month)	[a]1,647 (435)	[b]189 (50)	[b]189 (50)	1,647 (435)
Low enriched uranium kg/year (lb/year)	0	[c][Proprietary Information]	[Proprietary Information]	0

[a] The majority of the diesel fuel is consumed during the first three months of construction.
[b] Diesel fuel is used for backup generator.
[c] LEU needed for hot commissioning and initial RPF startup.
[d] LEU needed in Operation [Proprietary Information] for addition of second university reactor.
[e] LEU needed in Operation [Proprietary Information] for addition of third university reactor.

Materials consumed during the construction phase are shown in Table 19-7.

Table 19-7. Estimated Materials Consumed During Construction Phase

Material	Amount		Material	Amount	
Concrete	3,257 m^3	4,260 yd^3	Asphalt	245 m^3	320 yd^3
Structural steel	363 t	400 tons	Stone granular material	1,300 m^3	1,700 yd^3
Miscellaneous steel	45 t	50 tons	Roofing	4,645 m^2	50,000 ft^2
Steel liner	127 t	140 tons	Precast concrete	435 t	480 tons

19.2.1.4 Applicant for the Proposed Action

NWMI is an Oregon limited-liability company (LLC). The company was formed solely to provide ^{99}Mo to the medical industry. NWMI's owners are listed in Table 19-8.

Table 19-8. Northwest Medical Isotopes Ownership Summary

Company	State/structure	Membership interests
Samaritan Health Services, Inc.	Oregon, not-for-profit corporation	[Proprietary Information]
CAC IsoMed, LLC	Washington, limited-liability company	[Proprietary Information]
Orion Ventures, LLC	Oregon, limited-liability company	[Proprietary Information]
Oregon State University	Oregon, institute of higher education	[Proprietary Information]
Talents Venture Fund	Delaware, limited-liability company	[Proprietary Information]
Dignity Health	California, not-for-profit corporation	[Proprietary Information]
[a]Other		[Proprietary Information]
Total		**100%**

[a] Membership interests are less than 2 percent.

19.2.2 Radioisotope Production Facility Site Location and Layout

19.2.2.1 Site Location

The proposed 3.0 ha (7.4-acre) RPF site is situated within Discovery Ridge, north of Discovery Ridge Drive. Discovery Ridge is located in the City of Columbia, Boone County, Missouri. The site is situated in central Missouri, approximately 201 kilometer (km) (125 miles [mi]) east of Kansas City and 201 km (125 mi) west of St. Louis. The site is 7.2 km (4.5 mi) south of U.S. Interstate 70, just north of U.S. Highway 63 (Figure 19-4). The Missouri River lies 15.3 km (9.5 mi) west of the site. The site is located 5.6 km (3.5 mi) southeast of the main MU campus.

The approximate center of the RPF is longitude 92° 16' 34.63" and latitude 38° 54' 3.31" (NAD 83, 1983). Figure 19-5 illustrates the 8 km (5-mi) radius from the center of the facility and shows highways, rivers, and other local bodies of water.

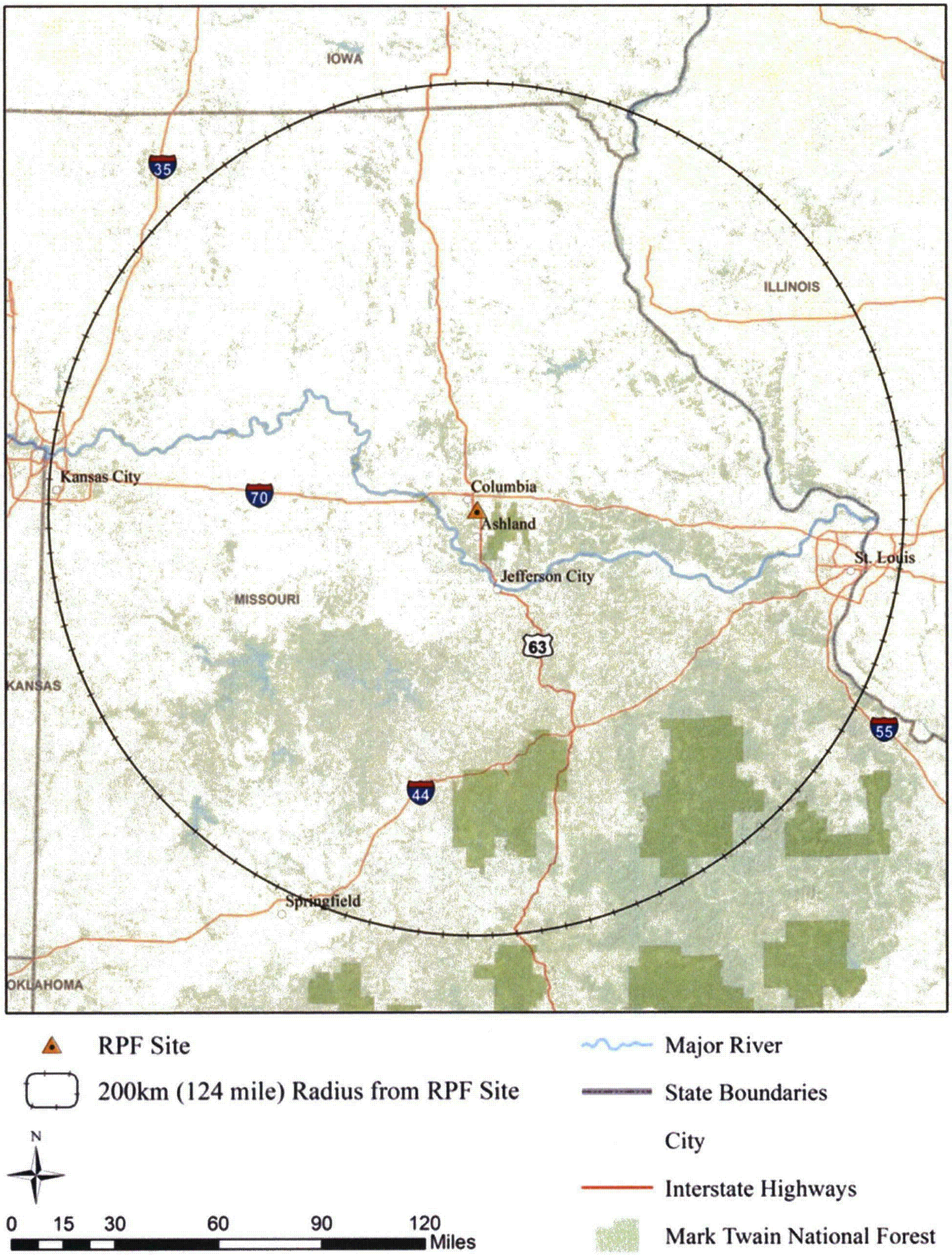


Figure 19-4. 200 km (124-mi) Radius with Cities and Roads

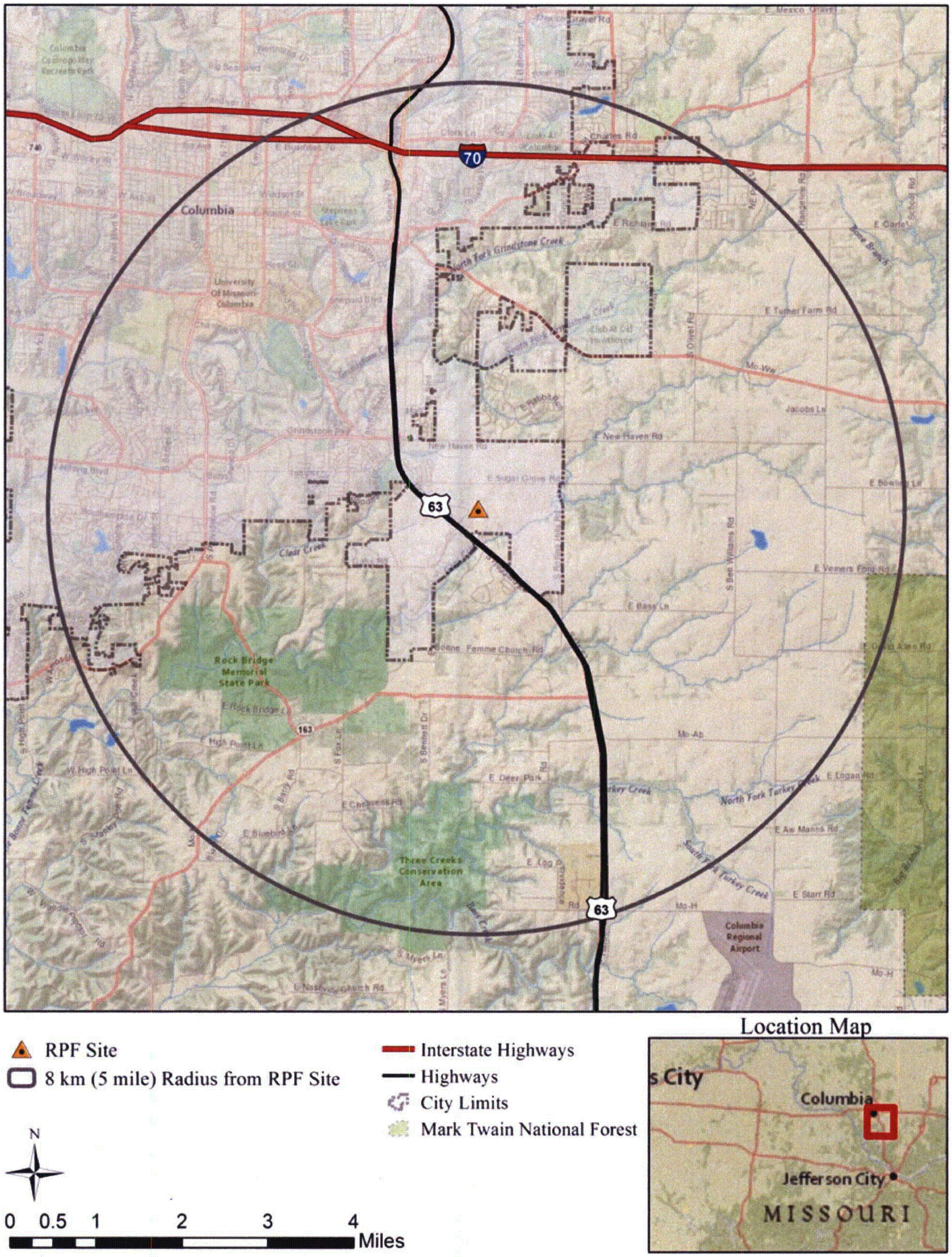


Figure 19-5. Illustration of 8 km (5-mi) Radius from the Center of the Facility

19.2.2.1.1 Population

The 2010 Census reported that Columbia had a population of 108,500, which increased by 20.1 percent over the 10 preceding years (USCB, 2010a/b). Ashland is located approximately 14.5 km (9 mi) south of the proposed RPF site and had a 2010 Census population of 3,707, which increased 50 percent over the 10 preceding years. The population of Columbia resides primarily north-northwest of the proposed site. The 2010 Census Boone County population was 162,642 (USCB, 2010a/b). In the fall of 2012, MU had a population of approximately 34,748 students (MU, 2013).

19.2.2.1.1.1 Sensitive Populations

Table 19-9 provides a list of the sensitive populations (e.g., schools, daycares, retirement homes) within a 5-mi radius of the proposed RPF site. The list was developed using multiple sources and surveys. Google Earth was used to determine the distances from the site.

Table 19-9. Sensitive Populations (2 pages)

Facility	Distance		General direction	Facility	Distance		General direction
	km	mi			km	mi	
Resident							
Nearest full-time resident	0.43	0.27	South	Sunset Mobile Home Park	0.93	0.58	Northwest
Full-time resident	0.58	0.36	Northwest	High Hill Courts Mobile Home	1.99	1.24	Southeast
Public Schools							
New Haven Elementary School	1.6	1.0	Northwest	Benton Elementary School	7.2	4.5	Northwest
Rock Bridge High School	5.25	3.26	West	Hickman High School	8.52	5.3	Northwest
Mill Creek Elementary School	8.55	5.31	West	Lee Elementary School	6.90	4.22	Northwest
Rock Bridge Elementary School	5.12	3.18	West	Field Elementary School	7.96	4.95	Northwest
Gentry Middle School	6.1	3.8	West	Jefferson Junior High School	7.82	4.86	Northwest
Cedar Ridge Elementary School	4.08	2.54	North	Grant Elementary School	7.85	4.88	Northwest
Shepard Boulevard Elementary School	4.55	2.83	Northwest	Douglas High School	7.82	4.86	Northwest
Colleges/Universities							
University of Missouri-Columbia	6.1	3.8	Northwest	Bryan University -Columbia	2.22	1.38	Northwest
Western Governors University Missouri	2.16	1.34	Northwest	Steven's College	6.92	4.3	Northwest
William Woods University	2.33	1.45	Northwest				
Private							
Christian Chapel Academy	5.13	3.19	North	Windsor Street Montessori	6.63	4.12	Northwest
Little Miracles Preschool	2.8	1.74	North	Fr. Tolton Catholic High School	1.42	0.88	Southwest
Children's House Montessori	6.36	3.95	Northwest	Islamic School of Columbia	7.26	4.51	Northwest

Table 19-9. Sensitive Populations (2 pages)

Facility	Distance km	Distance mi	General direction	Facility	Distance km	Distance mi	General direction
Child Care/Preschools							
Rock Bridge Child Development	5.5	3.4	West	Community Nursery School-Green Meadows Preschool	7.2	4.5	Northwest
Green Meadows Preschool	6.92	4.3	West	Tiger Tots Child Development Center	7.43	4.62	Northwest
Country Day School	3.14	1.95	Southeast	End of the Rainbow	3.69	2.29	Northwest
Luke's Child Care and Preschool	3.62	2.25	North	Academy of Early Childhood Learning	5.46	3.39	North
Apple School	5.1	3.2	West	Sylvan Learning Center	5.52	3.43	North
Down to Earth Preschool	5.8	3.6	West				
Retirement/Assisted Living Facilities							
Lenoir Woods Senior Living	1.46	0.91	Northwest	Columbia Manor Care Center	2.99	1.86	West
Tiger Place	2.54	1.58	Northwest	Boone Landing	5.97	3.71	North
Bluff Creek Terrace	2.53	1.57	Northwest				
Hospitals							
Providence Urgent Care	5.38	3.34	West	Green Meadows Pediatric and Adolescent Medicine	5.95	3.7	West
University Hospital Clinic	6.2	3.85	Northwest	University Physicians-Urgent Care	5.97	3.71	Northwest
Missouri Orthopedic Institute	5.83	3.62	Northwest	University of Columbia Hospital	6.13	3.81	Northwest
Harry S. Truman Memorial Veterans' Hospital	6.1	3.8	Northwest	Ellis Fischel Cancer Center	5.95	3.7	Northwest
Pediatric Plastic Surgery, University of Missouri Children's Hospital	6.16	3.83	Northwest	University of Missouri, Mohs & Dermatology Surgery Clinic	5.95	3.7	Northwest
Boone Hospital Center	6.39	3.97	Northwest	Children's Hospital	6.3	3.92	North

19.2.2.2 Site Layout

The RPF site is 3.0 ha (7.4-acre) and is located entirely on property owned by MU. Figure 19-6 shows a footprint of the major structures, site layout, fence line, and site boundary (Lot 15). The major structures include the RPF, Waste Staging and Shipping Building, and Diesel Generator Building. Additionally, the site has an Administration Building and Security Stations. These major facilities also receive, store/hold, or process chemicals, oil, diesel fuel, and other hazardous and radioactive materials. The site presently consists of grass fields and is primarily relatively flat surfaces at an elevation of 231 m (758 ft). Access to the site is provided from Discovery Drive and Discovery Parkway.

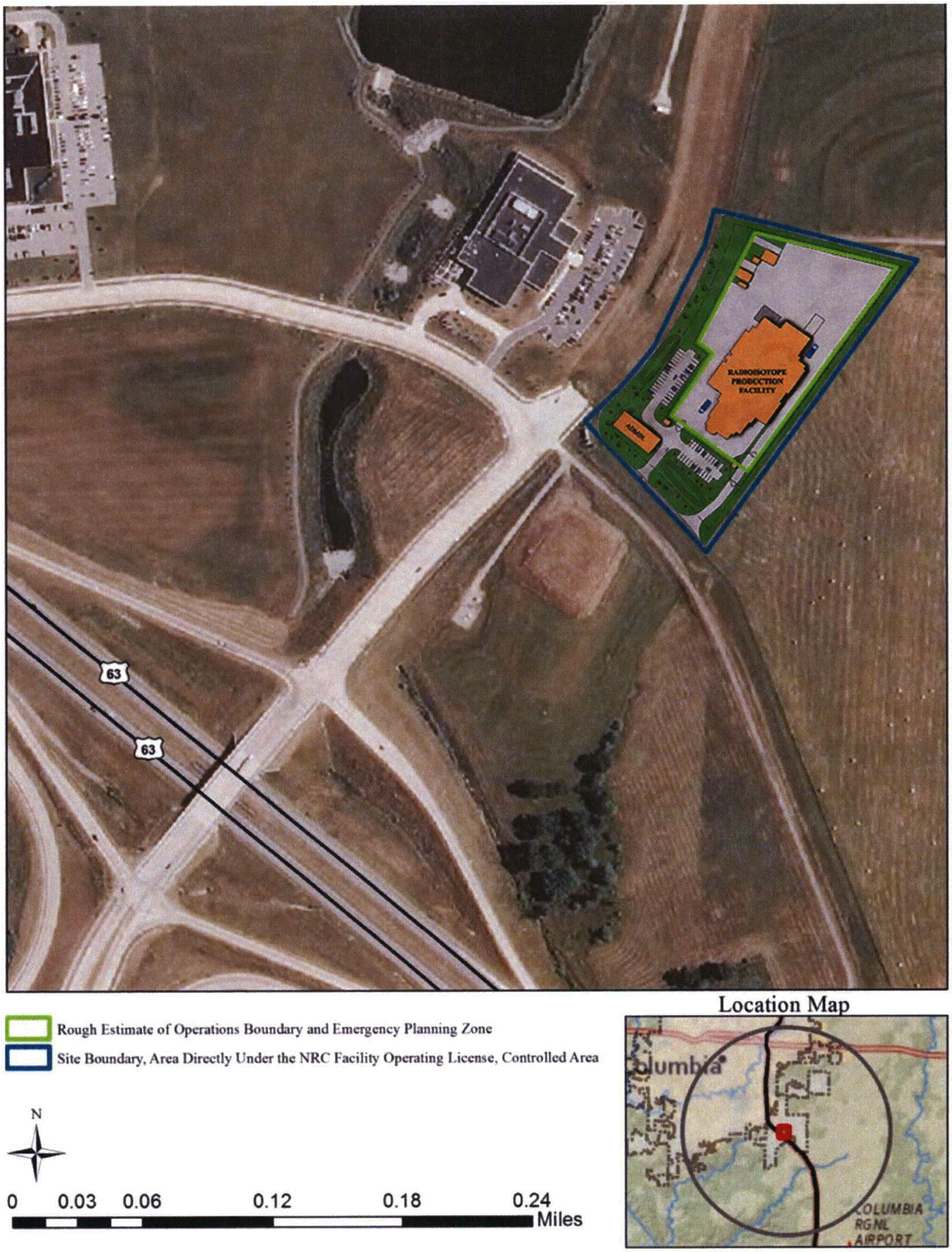


Figure 19-6. Radioisotope Production Facility Site Boundary

The RPF main building is approximately 106.7 m (350 ft) long and 56.4 m (185 ft) wide. The height above grade is 14 m (46 ft) for the mechanical/electrical bay roof, 19.8 m (65 ft) for the high bay roof, and 22.9 m (75 ft) for the facility stacks. The site is enclosed by perimeter fencing to satisfy safeguards and security and other regulatory requirements. The total fenced area includes paved roads laid out as appropriate for the turning radius of tractor/trailers used to transport the irradiated target shipping and waste handling casks.

19.2.2.3 Infrastructure Improvements

Discovery Ridge has the infrastructure (power, sewer, and water) required to support the proposed RPF. Sanitary sewer, electric power, municipal water, and natural gas are installed from the facility to the utility connections presently located at the southwest corner of the site.

19.2.2.4 Existing Infrastructure

The RPF site has no existing underground storage tanks, wells, pipelines, water supply, sewage, or stormwater systems.

19.2.2.5 Other Nearby Facilities/Buildings

Analytical Bio-Chemistry Laboratories – Analytical Bio-Chemistry Laboratories, Inc. (ABC Laboratories), is located approximately 0.48 km (0.3 mi) west of the proposed RPF within Discovery Ridge. ABC Laboratories is a contract research organization that delivers a broad array of product development and analytical testing services to the pharmaceutical, biotechnology, animal health, crop protection, and chemical industries. The facility is an 8,361 square meter (m^2) (90,000-square foot [ft^2]) facility that includes chemical and biochemical laboratories and associated systems and equipment. The facility is a RCRA large quantity generator-permitted facility.

Research and Diagnostic Laboratory Facility – The Research and Diagnostic Laboratory (RADIL) facility, located approximately 0.16 km (0.1 mi) northwest of the proposed RPF within Discovery Ridge. RADIL is owned by IDEXX Laboratories, Inc., who purchased the facility from the MU College of Veterinary Medicine. The 5,667 m^2 (61,000 ft^2) facility provides health monitoring and diagnostic testing services to bioresearch customers. The facility is a RCRA small quantity generator-permitted facility.

19.2.2.6 Monitoring Stations

The need for monitoring stations is discussed in the following sections:

- Air monitoring – Section 19.4.2.2
- Groundwater monitoring – Section 19.4.4.3
- Surface water monitoring – Section 19.4.4.3
- Meteorological monitoring – Section 19.4.2.2.5
- Ecological monitoring – Section 19.4.5.4
- Radiological monitoring – Section 19.4.8.4

19.2.3 Radioisotope Production Facility Description

The proposed RPF would support target fabrication, recovery and purification of the ^{99}Mo product from irradiated LEU targets that would be generated by irradiation in multiple university research reactors, and uranium recovery and recycle to produce ^{99}Mo. Figure 19-7 shows the proposed site layout, including the RPF, adjacent administration and support buildings, security buildings and associated security fence.

Figure 19-7. Radioisotope Production Facility Site Layout

Figure 19-8 is first level general layout of the RPF. Figure 19-9 and Figure 19-10 are preliminary layouts of the first level and second level, respectively, of the RPF. A mezzanine area above a portion of the process area would be for utility, ventilation and offgas equipment. The following sections provide a description of the major rooms included in the facility layout.

The first level (excluding the tank pit area) and second levels of the RPF are currently estimated to contain approximately 4,282 m^2 (46,088 ft^2) and 1,569 m^2 (16,884 ft^2) of floor space, respectively. The processing hot cell and waste management temporary storage floor space area is approximately 544 m^2 (5,857 ft^2). The maximum height of the building is 19.8 m (65 ft) with a maximum stack height of 22.9 m (75 ft). The depth of the processing hot cell belowgrade, without footers, is 4.6 m (15 ft) of enclosure height in rooms containing process equipment.

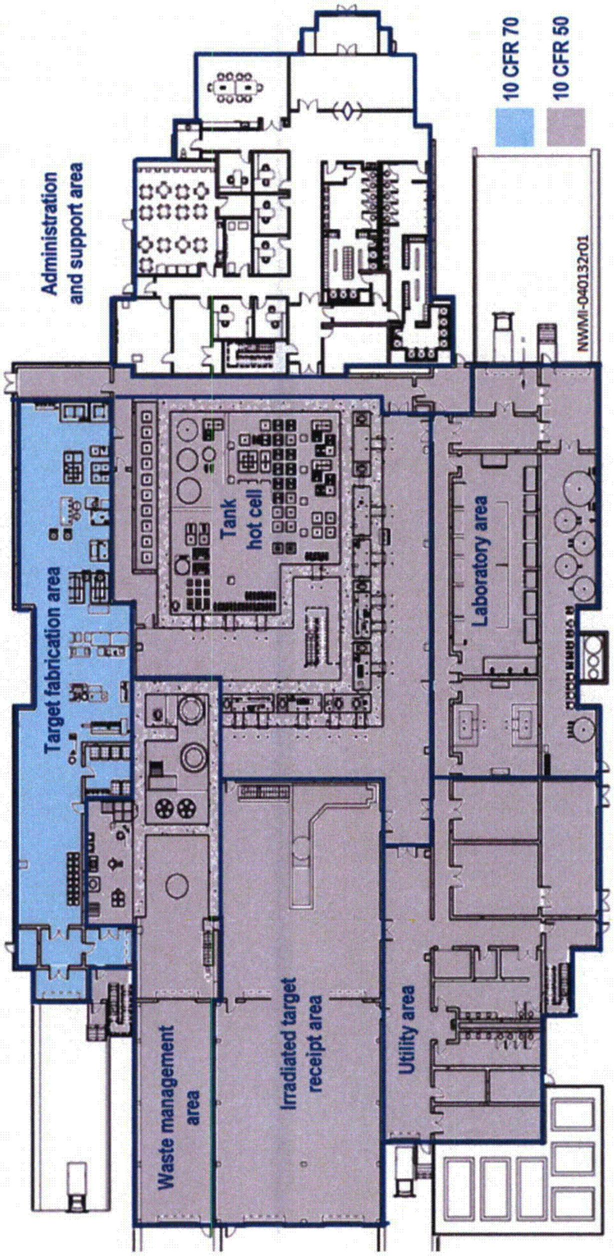


Figure 19-8. General Layout of the Radioisotope Production Facility

[Proprietary Information]

Figure 19-9. Preliminary Layout of the Radioisotope Production Facility First Level Floor Plan

[Proprietary Information]

Figure 19-10. Preliminary Layout of the Radioisotope Production Facility Second Level Floor Plan

Figure 19-11 illustrates the hot cell details for target disassembly dissolution, Mo recovery and purification, uranium recovery and recycle, and waste management.

[Proprietary Information]

Figure 19-11. Radioisotope Production Facility Hot Cell Details

19.2.3.1 Process Description

A flow diagram of the primary process to be performed by the proposed RPF is provided in Figure 19-12.

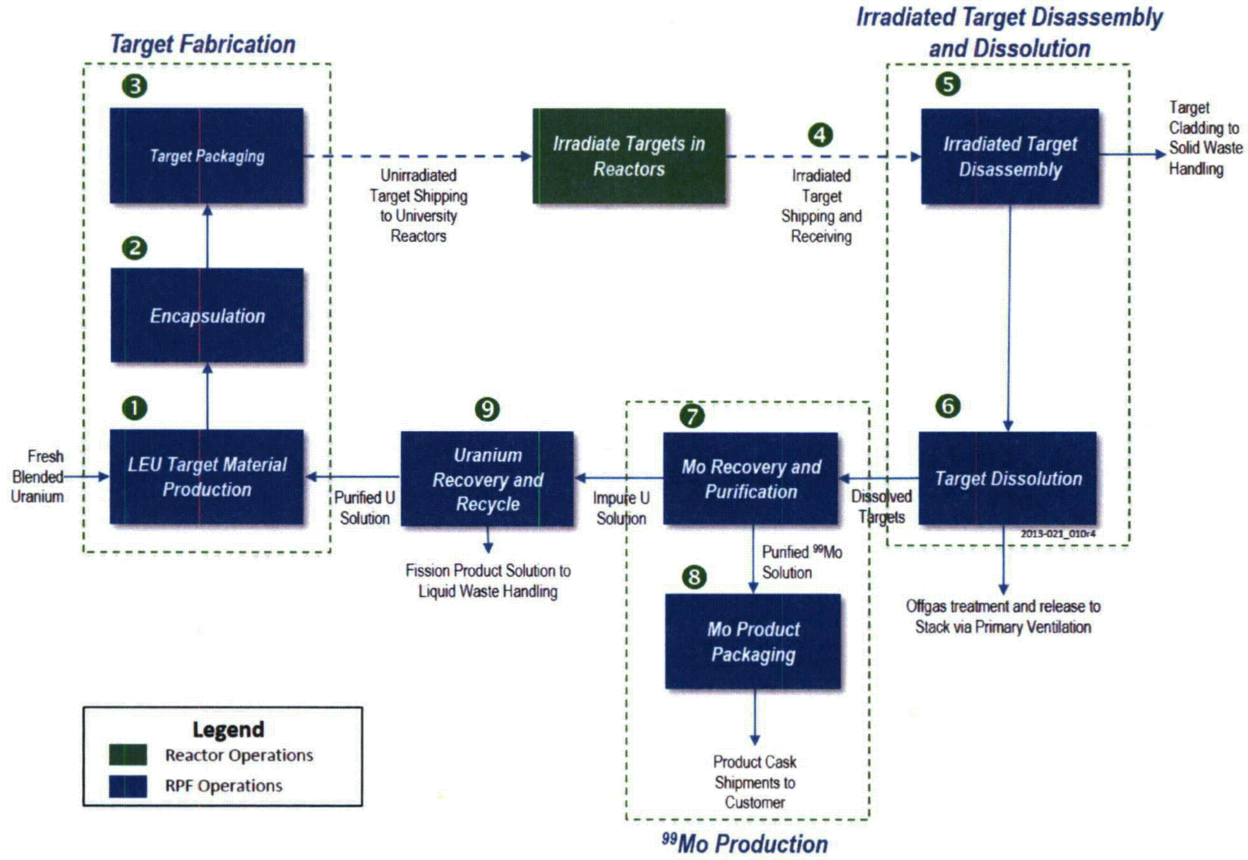


Figure 19-12. Radioisotope Production Facility Block Flow Diagram

RPF operations include the following general process steps (which correspond with the above figure).

1. LEU target material is fabricated using a combination of fresh LEU and recycled uranium.
2. Target material is encapsulated using metal cladding to contain the LEU and fission products produced during irradiation.
3. Fabricated targets are packaged and shipped to university reactors for irradiation.
4. After irradiation, targets are shipped back to the RPF.
5. Irradiated targets are disassembled and metal cladding is removed.
6. Targets are then dissolved into a solution for processing.
7. Dissolved LEU solution is processed to recover and purify ^{99}Mo.
8. Purified ^{99}Mo is packaged in certified shipping containers and shipped to a radiopharmaceutical distributor.
9. LEU solution is treated to recover uranium and remove trace contaminants and is recycled back to Step 1 to be made into new targets via the target fabrication system.

All process wastes that contain unwanted isotopes are converted to a disposal form by the waste handling system, where the wastes are placed in casks for shipment to a disposal site. Offgases are captured and treated through appropriate treatment systems and then released through a stack.

19.2.3.1.1 Target Fabrication Summary (Steps ❶, ❷, and ❸)

The target fabrication process converts fresh and recycled uranium into LEU target material, which is then loaded into target hardware for shipping to the reactors for irradiation. The material being processed in the target fabrication area requires no shielding; the equipment is contact-handled.

LEU target material production (Step ❶) – LEU target material is produced using an internal gelation process. The material is produced from a combination of recycled uranyl nitrate, fresh uranium metal, and uranium compounds recycled from various points in the target fabrication system. The recycled uranyl nitrate is converted to acid-deficient uranyl nitrate (ADUN) using a solvent extraction process, which selectively removes nitrate ions from the solution. The resulting ADUN is mixed with the uranyl nitrate produced by dissolution of fresh uranium. This ADUN is evaporated to achieve the desired uranium concentration, and is then chilled before mixing with urea and hydroxymethyltetramine (HMTA) to form the gelation broth. This broth is injected into a column of heated silicone oil. At the base of the column, the LEU target material is filtered from the oil and washed with a solvent, ammonium hydroxide and water. The target material is then reduced in a stream of dilute hydrogen within a furnace. The LEU target material is sampled and analyzed to ensure that it meets quality requirements before routing to the target fabrication system.

Encapsulation (Step ❷) – LEU target material is loaded into the target hardware. This hardware is prefabricated and cleaned before entering the facility. The targets are filled with LEU target materials and helium cover gas. Once the targets have been loaded and welded, they undergo inspection and quality assurance (QA) checks, including leak testing. Targets that pass the QA checks are shipped to the university reactors for irradiation. Targets that fail the QA checks are disassembled. The LEU target material is recycled, and the hardware is cleaned and disposed of as nonradioactive scrap.

Target packaging and shipment (Step ❸) – Assembled targets are loaded into shipping casks for transport to the university reactors. Transport will be via ground transportation.

19.2.3.1.2 Irradiated Target Receipt, Disassembly, and Dissolution Summary (Steps ❹, ❺, and ❻)

Target receipt and disassembly (Steps ❹ and ❺) – The irradiated targets are received in shielded shipping casks. The irradiated LEU targets are moved into the hot cell via a below-grade tunnel to the hot cell access point that mates up with either the shipping cask or a transfer cask. The targets are disassembled by puncturing the target, collecting any fission product gases, severing the target in half, and transferring the irradiated LEU target material into a transfer container. The spent target are inspected and disposed of as solid waste.

Target dissolution (Step ❻) – The target dissolution process is operated in a "batch" fashion, with the irradiated LEU target material transferred into a dissolver. The LEU material is dissolved in hot nitric acid. The offgas containing the fission product gases goes through a series of cleanup columns. The nitrogen oxides (NO_x) is removed by a reflux condenser and several NO_x absorbers, the fission product gases (noble and iodine) are captured on absorbers, and the remaining gas is filtered and discharged into the process ventilation header. The dissolver solution is diluted, cooled, filtered, and pumped to the ^{99}Mo system feed tank. Only one of the two dissolvers is planned to be actively dissolving LEU target material at a time.

19.2.3.1.3 Molybdenum-99 Product Recovery and Purification System (Steps ❼ and ❽)

The dissolver solution from the target dissolution operation is processed to purify the ^{99}Mo. The uranium-containing solutions from the ^{99}Mo ion exchange (IX) columns are transferred to the uranium recovery system. The remaining waste solutions are sent to low- or high-dose waste storage tanks.

Mo recovery and purification (Step ❼) – The dissolver solution from the target dissolution operation is pumped through the first IX column (Mo recovery). The ^{99}Mo and trace components are absorbed onto the media. The uranium and most of the fission products and other contaminates flow through the column and are sent to the lag storage tanks in the uranium recovery and recycle system. The ^{99}Mo is eluted from the first column and purify in the second and third IX columns. The product purification process primarily consists of a series of chemical adjustments and IX columns to remove unwanted isotopes from the ^{99}Mo product solution.

^{99}Mo product packaging and shipping (Step ❽) – Product solution is sampled to verify compliance with acceptance criteria after a final chemical adjustment. The product solution in small vials is then placed into shipping containers that are sequentially loaded into shipping casks. The casks are removed from the hot cell, surveyed, and manifested for transport to the customer. ^{99}Mo product is transported via air or ground transportation depending on which radiopharmaceutical distributor is receiving the shipment.

19.2.3.1.4 Uranium Recovery and Recycle Summary (Step ❾)

The uranium process system consists of solution storage vessels, IX columns, and concentrators for uranium recovery and recycle. The lag storage tanks minimize upstream processing delays and provide several weeks of decay time before the material is processed through the system.

First cycle uranium recovery – The LEU stream from the first cycle molybdenum IX column is held in lag storage tanks to allow selected radionuclides to decay. The solution is then diluted and pumped through the first IX columns to separate the bulk of the fission product contaminants from the uranium. The waste is sampled and sent to the high-dose liquid waste accumulation tank. The uranium is eluated from the IX columns, and a concentrator/condenser is used to control the volume of the uranium interim product. The condensate is send to the low-dose liquid waste accumulation tank.

Second cycle uranium recycle – The interim uranium product solution is processed through a second stage IX column to remove trace contaminates. The waste is sampled and sent to the high-dose liquid waste accumulation tank. The uranium is eluated from the IX columns, and a concentrator/condenser is used to control the volume of the recycled uranium product. The condensate is sent to the low-dose liquid waste accumulation tank. The final uranium product solution is sampled to confirm that it meets the recycle specification.

Product uranium lag storage – This subsystem consists of a series of solution storage vessels. The vessels allow the time necessary for uranium-237 (^{237}U) to decay to contact-handled levels in the uranium product solutions. The decayed uranium product is returned to target fabrication.

19.2.3.1.5 Waste Management System Description

The waste management system is divided into three subsystems: (1) the liquid waste system, (2) the solid waste system, and (3) specialty waste systems.

Liquid waste system – The liquid waste disposal system consists of storage tanks for accumulating waste liquids and adjusting the waste composition. Liquid waste is split into high-dose and low-dose streams by concentration. The high-dose fraction is further concentrated, adjusted, and mixed with adsorbent material. A portion of the low-dose fraction is expected to be suitable for recycle to selected systems as process water. Water that is not recycled is adjusted and then mixed with an adsorbent material. Both solidified streams are held for decay and shipped to a disposal facility.

Solid waste system – The solid waste disposal system consists of an area for collection, size reduction, and staging of solid wastes. The solids are placed in a waste drum and encapsulated by adding a cement material to fill voids remaining within the drum. The solidified waste is held for decay and shipped to a disposal facility.

Specialty waste system – A specialty waste disposal system is based on addressing small quantities of unique wastes generated. The goal is to reuse as much of the material as possible. Examples of these processes may include organic and non-organic reclamation processes and silicone oil waste accumulation. These waste streams are containerized, stabilized, as appropriate, and shipped offsite for treatment and disposal.

19.2.3.1.6 Process Offgas Systems

The process offgas subsystem is connected directly to the process vessels and maintains a negative pressure within the vessels. Process vessel ventilation systems include a set of subsystems that are specialized to the equipment that the subsystems support. These systems merge together at the process offgas filter train.

Dissolver offgas subsystem – The dissolver offgas subsystem is connected directly to the process vessels associated with the irradiated target dissolution process. There are two primary features of this system: (1) recover NO_x from the nitric acid dissolution of irradiated targets, and (2) capture fission product gases released from the irradiated targets. This subsystem is installed in the remote hot cell.

Iodine potential offgas subsystem – The iodine potential offgas subsystem is connected directly to process vessels or equipment that contain tellurium isotopes that decay and form iodine isotopes. Within this subsystem, an iodine capture system is included to ensure that any iodine evolving from the process is captured on the treatment media. After iodine treatment, the subsystem merges with the other process ventilation subsystems.

LEU target/target fabrication offgas subsystem – The microsphere/target offgas subsystem is connected directly to the process vessels and equipment that are associated with the wet portion of the microsphere/target fabrication process. Filtration is required for this subsystem prior to merging with the other process ventilation subsystems. There are controls/design features in place to maintain the reducing gas within flammability limits.

19.2.3.2 Facility Areas

19.2.3.2.1 Irradiated Target Receipt Bay

The irradiated target receipt bay is used to receive irradiated fuel elements in shipping casks loaded on semi-truck trailers. The traveling bridge crane is used to transfer a shipping cask from the trailer onto a transfer cart for transfer to the hot cells. The shipping cask/transfer cart is transferred from the receipt bay airspace through a doorway into the hot cell operating gallery. The cask is introduced to a shielded transfer port in the hot cell, where the cask is remotely opened and targets are removed and staged within the hot cell for disassembly.

19.2.3.2.2 Remote Hot Cells

Irradiated target processing is performed using equipment that is located in shielded hot cells to protect operating personnel from doses generated by radioactive materials. The hot cells provide remote operation and maintenance capabilities with features such as (1) shielding windows and in-cell and through-wall manipulators for equipment operation and maintenance, (2) access via cover blocks and bridge crane to support remote maintenance activities, and (3) equipment (e.g., pumps and valves) that remotely operated from outside the hot cell.

The hot cells and associated ventilation equipment also provide containment and confinement for the potential release of radioactive materials from a process vessel during maintenance activities or off-normal operating conditions. The hot cell area will have a criticality favorable floor/sump geometry configuration and high-efficiency particulate air (HEPA) filters on the ventilation inlets and outlets. The hot cell is divided up into the following areas:

- LEU target disassembly and dissolution area
- Mo recovery and purification area
- Uranium recovery and recycle area
- Operating gallery area
- Maintenance areas
- Remote support systems areas

Low-Enriched Uranium Target Disassembly and Dissolution Area

The disassembly area has a feature that mates with the shielded cask and enables the target basket with irradiated LEU targets to be placed in the hot cell. Two disassembly stations are currently envisioned as semi-automated devices that pick one target at a time from the shipping basket, puncture and delid the target, and pour target material into a transfer container. The spent target is inspected to ensure that it is empty, passed through to the waste management area, and disposed of as solid waste. The area also contains the dissolver vessels, dissolver offgas treatment equipment, and fission gas capture columns. The disassembly stations are supported with leaded windows and/or cameras and master-slave manipulators.

Molybdenum-99 Recovery and Purification Area

Cells are included in the remote hot cell to house equipment associated with the Mo recovery and purification system. The cells include a series of small IX columns with containers, peristaltic pumps, and collection tanks. Operations and maintenance of the process are performed by the through-wall manipulators. An egress point is included for load-in and load-out of the ^{99}Mo shipping cask. This area of the hot cell will have design features that support FDA requirements.

Uranium Recovery and Recycle Area

Equipment associated with the LEU recovery and recycle system is also located within the remote hot cell area. This equipment will be much larger than the small Mo recovery and purification equipment, and use a large portion of the remote hot cell. The process equipment includes a series of IX columns; lag storage, feed, and product tanks to support operation of IX columns; and concentrator systems. The process equipment is skid-mounted, which enables remote replacement and ensures critically safe spacing between skids.

Operating Gallery Area

The operating gallery is situated adjacent to the hot cell. The operating gallery is an area used by personnel to physically operate remote wall-mounted manipulators. Local control stations are provided in the operating gallery to support process operations. The operating gallery width is sufficient to allow removal of a wall-mounted manipulator for maintenance or repair. After removal from the wall, a manipulator is transported via a cart system to the maintenance area where actual repairs are performed.

Maintenance Areas

Two maintenance areas are used for facility equipment maintenance: the maintenance shop and the manipulator repair room.

Remote Support Systems

Remotely operated equipment is used to perform the core operations of processing irradiated targets, recovering ^{99}Mo for shipment to customers, and recycling LEU for fabrication into targets for future irradiation. These operations are backed by remotely operated support systems, including the main crane and manipulator arms. These two systems provide the ability to keep the process in operation for years.

Along with the manipulator arms, the main crane provides the heavy-lifting capacity needed to lift the hot cell cover blocks, remove nonfunctional items from the remote hot cell, and bring in replacement components. An additional crane is provided for remote operations and lifting waste packages in the waste management area.

19.2.3.2.3 Target Fabrication Area

The target fabrication area contains equipment associated with the LEU target material and target fabrication systems. Material processed by the system is unirradiated LEU, obtained as feed from DOE, and LEU recycled from processing irradiated targets. Recycled LEU is purified in the remote hot cell and transferred as a solution to the microsphere fabrication vessels. Verification measurements are performed on the purified recycled LEU solutions prior to transfer into the fabrication area to confirm that the recycled LEU material satisfies criteria that allow processing in the unshielded process enclosures.

The microsphere/target fabrication area includes the following sub-areas:

- **Target fabrication wet area** – The wet area contains the process equipment for conversion of uranium compounds to LEU target material. Most of the equipment processes aqueous solutions of uranium. The equipment includes concentrators, dissolvers, liquid-liquid contactors, lag storage and blending tanks, columns for forming and washing LEU target materials, a filter system, furnace boat loading and transfer systems, and furnaces for drying and reducing the LEU target material. The LEU target material is manually transferred from the wet area to the dry area.
- **Target fabrication dry area** – The dry area is used to encapsulate LEU target material in the target hardware. Activities performed in this area are primarily receipt and inspection of target hardware components, loading LEU target material into the target, filling the target with helium, and seal welding the targets.
- **Target fabrication QA/laboratory area** – This area is used to perform the various tests and inspections for monitoring and QA of the target fabrication processes. Tests are performed on liquid solutions, LEU target material, and assembled targets.
- **Storage areas** – These are secure rooms within the target fabrication area that store materials used by the above processes. These rooms contain storage racks that segregate raw and in-process materials from the final product.

19.2.3.2.4 Waste Management Area

The waste management area includes shielded enclosures for tanks collecting liquid waste and containers used to stage solid wastes generated by the process systems. Portions of the waste management system that are dedicated for high-dose liquid waste are included in the remote hot cell. There are three shielded areas in the waste management area: (1) the high-integrity container (HIC) vault, where filled waste containers are held for several months to allow short-lived radioisotopes to decay to lower doses, (2) the hot cell solid waste export area, where equipment and empty targets are passed out of the hot cell, and (3) the solidification cell, where liquid waste is processed/mixed with materials to prepare waste packages for disposal.

The solid waste is moved to the waste loading area, where the waste is loaded into a shipping cask (typically already on a truck trailer) to be transported to a disposal site. The waste management area is serviced by a bridge crane.

19.2.3.2.5 Mechanical/Electrical Rooms

The mechanical/electrical rooms are located on the second floor on both sides of the hot cell. The mechanical/electrical rooms house electrical systems, motor control centers, pumps, boilers, air compressors, and ventilation supply equipment. The heating, ventilation, and air-conditioning (HVAC) chillers are located outside of the facility, in the same area as the process water chillers. The mechanical room over the laboratory/chemical make-up areas houses the exhaust fans and filter trains.

19.2.3.2.6 Process Offgas Room

The process offgas room is connected directly to the process vessel and process offgas subsystems to treat the stream and maintain negative pressure within the vessels. The process offgas room contains absorbers, filters trains, and fans. Process offgas is discharged from the primary building exhaust system.

19.2.3.2.7 Laboratory and Research and Development Hot Cell

An analytical laboratory and research and development hot cell area support the production of the ^{99}Mo product and recycle of uranium. Samples from the process are collected, transported to the laboratory, and prepared in the laboratory hot cell.

Other laboratory features include the following:

- Hoods and/or gloveboxes to complete sample preparation, waste handling, and standards preparations
- Rooms with specialty instruments, including an inductively coupled plasma mass spectrometry (ICP-MS)—a gamma spectroscopy system, an alpha spectroscopy system, a liquid scintillation system, and a beta-counting system
- Chemical and laboratory supplies storage
- Bench-top systems (e.g., balances, pH meters, ion-chromatography)

19.2.3.2.8 Chemical Make-up and Gas Storage Room

The chemical make-up room includes tanks supplying aqueous chemicals to the process systems, flammable material storage cabinets used to segregate incompatible materials, and storage of chemical solids used in the process systems. The gas distribution room serves as a location for storage of small quantity gases (stored in gas cylinders) and distribution manifolds. Large quantities of gases are stored outside of the RPF in appropriate storage tanks or trailers. These areas are designed to segregate incompatible chemicals.

19.2.3.2.9 Raw Materials and Molybdenum-99 Product Shipping and Receiving Areas

Two separate access points are proposed to move process materials into and out of the facility and ship ^{99}Mo product to the radiopharmaceutical distributors. Both access points are truck bays that interface with process areas near the chemical make-up room. The ^{99}Mo product bay functions as an airlock as part of the confinement ventilation control strategy for exporting the casks transported by a cargo vehicle. The second access point next to the ^{99}Mo product area is a shipping/receiving room and loading dock for the movement of smaller packages using handcarts or forklift. This area is the planned location for the receipt of chemicals and will have a pad/berm for spill protection and collection.

19.2.3.2.10 Support Staff Areas

The support staff areas are an annex to the RPF and include various areas supporting the process. The support staff areas include a shift office, health physics office, break room, support offices/workroom, change rooms/bathrooms, storage areas, and personnel airlock.

19.2.3.2.11 Control Room

The control room houses the process control system for operating and monitoring the facility. The control room door into the facility is equipped with controlled access. The control console has two or three operator interface stations or human-machine interfaces (one being a dedicated engineering interface), a master programmable logic controller or distributed controller, and all related and necessary cabinetry and subcomponents (e.g., power supplies and uninterruptable power supply). This control system is supported by a data highway of sensing instrument signals in the facility process areas that are gathered throughout the facility by an Ethernet communication-based interface backbone and brought into the control room and onto the console displays.

Dedicated controllers and human-machine monitoring interfaces or stations for other equipment systems are also in the control room. A control panel for all facility on-site and off-site (if required) communications (e.g., telephone, intercom) will potentially be located in the control room.

19.2.3.2.12 General Ventilation System

The facility ventilation system maintains a series of cascading pressure zones to draw air from the cleanest areas of the facility to the most contaminated areas. Zone IV is a clean zone and is independent of the other ventilation zones. Zone IV will be slightly positively pressurized with respect to the atmosphere. Zone III is the cleanest of the potentially contaminated areas, with each subsequent zone being more contaminated and having lower pressures. Table 19-10 defines the ventilation zone applicable to major spaces. Figure 19-13 graphically presents the ventilation zone for the first level of the RPF.

A common supply air system provides 100 percent outdoor air to all Zone III areas and some Zone II areas that require make-up air in addition to that cascaded from Zone III. Three separate exhaust systems maintain zone pressure differentials and containment: (1) the Zone I exhaust system services the hot cell, waste loading areas, target fabrication enclosures, and process offgas subsystems in Zone I; (2) the Zone II/III exhaust system services exhaust flow needs from Zone II and Zone III in excess of flow cascaded to interior zones; and (3) a laboratory exhaust system services fume hoods in the laboratory area.

Table 19-10. Facility Areas and Respective Confinement Zones

Area	Zone
Hot cells (production)	I
Tank hot cell	I
Solid waste treatment hot cell	I
High-dose waste solidification hot cell	I
Uranium decay and accountability hot cell	I
HIC vault	I
Analytical laboratory gloveboxes	I
R&D hot cell laboratory hot cells	I
Target fabrication room and enclosures	II
Utility room	II
Analytical laboratory room and hoods	II
R&D hot cell laboratory room and hoods	II
Waste loading hot cell	II
Maintenance gallery	II
Manipulator maintenance room	II
Exhaust filter room	II
Airlocks[a]	II, III
Irradiated target basket receipt bay	III
Waste loading truck bay	III
Operating gallery and corridor	III
Electrical/mechanical supply room	III
Chemical supply room	III
Corridors	III
Decontamination room	III
Loading docks	IV
Waste management loading bay	IV
Irradiated target receipt truck bay	IV
Maintenance room	IV
Support staff areas	IV

[a] Confinement zone of airlocks will be dependent on the two adjacent zones being connected.
HIC = high-integrity container.
R&D = research and development.

[Proprietary Information]

Figure 19-13. First-Level Confinement of the Radioisotope Production Facility

The supply air is conditioned using filters, heater coils, and cooling coils to meet the requirements of each space. Abatement technologies (primarily HEPA filtration and activated carbon) are used to ensure that air exhausted to the atmosphere meets NESHAP and applicable State law. A stack monitoring system is employed to demonstrate compliance with the stated regulatory requirements for exhaust.

The systems and components of the main ventilation system are described in the following subsections.

Supply Air Subsystem

The supply air system provides filtered and conditioned air to all Zone III spaces and some Zone II spaces at a ventilation rate of 100 percent outside air. The three supply air handling units are sized at 50 percent capacity each, for redundancy. Two of the three units will be operating, while the third is on standby. Each unit consists of an outdoor air louver, filters, a cooling coil, a heating coil, a heat recovery coil, isolation dampers, and a fan.

Variable-speed fans are modulated to control the pressure in the common air plenum. The heating and cooling coils in each air-handling unit are controlled based on a common supply air temperature sensor. Reheat coils are provided in the supply ducts to each space, as required, to further condition the supply air, based on space temperature thermostats.

Exhaust Air Subsystems

Four exhaust air subsystems are provided: Zone I exhaust, Zone II/III exhaust, laboratory exhaust, and process offgas exhaust. Each exhaust system is provided with two 100 percent capacity exhaust fans and filter trains for complete redundancy on all exhaust subsystems. This redundancy is important to ensure confinement ventilation pressure differentials are maintained at all times. Each exhaust filter train consists of prefilters, two stages of HEPA filters, carbon adsorbers, and isolation dampers. Exhaust ducts upstream of the filter trains are round to minimize areas where contamination can accumulate, and are sized to minimize particulate settling in the duct. Each exhaust system has a separate stack, with the exception of the process offgas subsystem, which merges with the Zone I exhaust stream. A stack monitoring system is provided on each stack to demonstrate compliance with applicable State law.

Zone I Exhaust Subsystem

The Zone I exhaust system serves the hot cell, HIC loading area, and solid waste loading area. This exhaust system maintains Zone I spaces at negative pressure with respect to atmosphere. The disassembly station is maintained at a slightly lower pressure due to the increased likelihood of contamination in that area. All make-up air to Zone I spaces are cascaded from Zone II spaces. Space temperature control is not provided for Zone I spaces unless thermal loads are expected to cause temperatures to exceed equipment operating ranges without additional cooling. HEPA filters are included on both the inlet and outlet ducts to Zone I. The outlet HEPA filters minimize the spread of contamination from the hot cell into the ductwork leading to the exhaust filter train. The inlet HEPA filters prevent contamination spread in case of an upset condition that results in positive pressurization of Zone I spaces with respect to Zone II spaces. The process offgas subsystem enters the Zone I exhaust subsystem just upstream of the filter train.

Zone II/III Exhaust Subsystem

The Zone II/III exhaust system serves the Zone II spaces and those Zone III spaces that do not provide cascaded air flow into Zone II. This exhaust system maintains Zone II spaces at negative pressure and Zone III spaces at a less negative pressure with respect to atmosphere. Make-up air to Zone II spaces is either cascaded from Zone III spaces or supplied from the supply air subsystem to meet additional space conditioning needs. All make-up air to Zone III spaces is provided from the supply air subsystem.

Laboratory Exhaust Subsystem

The laboratory exhaust system provides fume hood and glovebox exhaust capability. This essentially is a Zone I system, but is separate from the main Zone I exhaust system to accommodate the large flow fluctuations from changing fume hood positions. These highly variable flow conditions are controlled better through a separate exhaust system. This exhaust system minimizes the potential pressure perturbations and control difficulties that could result from including the fume hoods on the main Zone I exhaust system. Make-up air for increased fume hood exhaust flow is supplied from the common supply air system.

Cleanroom Subsystem

The cleanroom subsystem is designed to provide filtered and conditioned air at an exchange rate to meet the standards of an ISO 14644-1, "Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness," Class 8 cleanroom. The cleanroom is maintained at a slightly positive pressure relative to its surroundings to ensure that unfiltered air does not infiltrate the cleanroom. Air inside the cleanroom is continually recirculated through a dedicated filtration system to remove internally generated contaminants. Air would be 100 percent recirculated, with the only air exchange with the surroundings of the cleanroom occurring through exfiltration and make-up air entering on the suction side of the fan. The cleanroom air handling unit and filters are located inside the hot cell and, therefore, must be remotely maintainable. Periodic cleanroom certification testing also needs to be performed remotely with permanently installed instrumentation.

19.2.3.2.13 Other Radioisotope Production Facility Support Buildings

External waste management storage and shipping building – The waste management building is approximately 111.5 m^2 (1,200 ft^2) and will provide additional waste storage and shipping preparation for radioactive waste prior to disposal.

Diesel generator building – The diesel generator building houses the RPF backup generator, which is used for temporary operation and safe shutdown of the RPF if required. The diesel fuel tank is stored aboveground next to the building, with an approximate volume of 3,785 liters (L) (1,000 gallons [gal]).

Security buildings – The RPF will have to two security buildings, one for personnel access and one for shipping and receiving of materials and waste. NWMI will establish, implement, and maintain its authorization program in accordance with NRC requirements.

19.2.4 Water Consumption and Treatment

19.2.4.1 Water Consumption

The water supply source for the proposed RPF is the municipal water system. Connection to this system will comply with applicable State or local requirements. Required ancillary equipment (e.g., pressure regulators, backflow preventers) is installed as required by local ordinances.

The demineralized water system supplies demineralized water to the process for water addition, flushing, and chemical dilution. The demineralized water system can also potentially provide make-up water to the steam boilers. Wash water is used to washdown the tractor/trailers.

Final flow rates and process needs are determined on completion of performance testing (e.g., fire protection systems). Additional pumps and regulators may be installed to meet the performance needs of the systems. Where appropriate, water recycle or reuse systems are employed. Lavatory and office supply water systems are provided. These systems are designed and installed in accordance with local code.

The RPF water flow rates and consumption data is summarized in Table 19-11. The chilled water and steam systems are closed-loop systems and require water during startup, with minimal make-up water requirements during operation.

Table 19-11. Radioisotope Production Facility Water Flow Rates and Consumption Information

Activity	[a]Annual demineralized water		Annual wash water	
	L	gal	L	gal
Target fabrication	25,000	6,600	–	–
Target disassembly and dissolution	1,500	400	–	–
Mo recovery and purification system	–	–	–	–
Uranium recovery and recycle system	500,410	132,200	–	–
Waste management	–	–	–	–
Laboratory facilities	2,000	530	–	–
Faculty support	2,000	530	360,000	95,100
Total	**530,910**	**140,260**	**360,000**	**95,100**
[b]Average daily use	2,042	539	1,385	366

[a] These numbers do not account for planned process recycle.

[b] Assumes 260 days of operation per year.

19.2.4.2 Water Sources Independent of Municipal or Commercial Supply

The RPF will not use water sources independent of the municipal or commercial supply.

19.2.4.3 Water Treatment

Potable water is provided through the public utility system and will require no additional treatment. Contaminated process wastewater storage and treatment systems are addressed in Section 19.2.7.3.

19.2.5 Cooling and Heating Dissipating Systems

19.2.5.1 Cooling Water Systems

The process chilled water system provides cooling for the process equipment. Cooling is required for condensing offgas from the concentrators and for cooling the process stream. Chilled water is delivered to cooling jackets in a closed loop system. Redundancy is provided for components that present a single-point failure risk in the process chilled water system to ensure that cooling remains available for continued production.

Air-cooled chillers are located outside of the RPF. These chillers are expected to be typical commercial HVAC chillers. Redundancy for cooling capacity is provided by sizing each of the three chillers at 50 percent of the design cooling capacity. Chilled water is circulated from the chillers to an intermediate heat exchanger in the secondary loop. The primary loop then circulates and distributes chilled water from the heat exchanger to the various process loads in a closed loop. The chilled water pumps are typical centrifugal pumps used in HVAC systems.

The intermediate heat exchanger is provided to minimize the risk of contamination spread outside of the facility in case of a process system leak into the chilled water system. To further minimize this risk, pressure differentials are maintained to ensure that flow is from lower contaminated systems into higher contaminated systems. The primary loop is maintained at a higher pressure than the process equipment, and the secondary loop is maintained at a higher pressure than the primary loop.

Some process cooling loads (e.g., the fission gas-trap and target fabrication equipment) require lower supply temperatures (e.g., below 0 degrees Celsius [°C]). These loads are served by standalone process chillers.

The RPF is designed to have zero liquid discharge from the radiologically controlled area (i.e., no liquid would be released from the facility).

19.2.5.2 Heating Systems

Process steam is used to provide heating for process equipment. Heating is required for the concentrators and process stream. The steam from the boilers flows to an intermediate heat exchanger in the secondary loop. The primary loop then circulates and distributes steam from the heat exchanger to the various process loads in a closed loop. The steam is assumed to be supplied to the heating jacket, condensed, and returned to the intermediate heat exchanger in a closed loop system. Redundancy is provided for components that present a single-point failure risk in the process steam system to ensure that heating remains available for continued production. Three electric boilers are located in the mechanical room of the facility. The boilers are assumed to be standard, commercially available, packaged high-pressure steam boilers. Each boiler is sized at 50 percent of the design capacity to provide redundancy for heating.

19.2.5.3 Heat Dissipation Systems

The RPF has no additional heat dissipation systems, besides the process chilled water system described in Section 19.2.5.1.

19.2.6 Auxiliary Systems

The compressed air system supplies instrument-quality (dry and oil-free) air to power air-actuated valves and dampers and for instruments that require compressed air (e.g., bubbler tube-level indicators). The compressed air system can also provide process air, although these loads are undefined.

The system is assumed to consist of a packaged air compressor system, with the compressor mounted on the receiver tank with associated filters, coolers, and pressure relief. A separate modular, heatless desiccant-type air dryer is provided. Process air can be taken directly from the air receiver, prior to drying and further filtering.

The HVAC chillers are located outside the facility, in the same area as the process chilled water chillers. The hot water boilers are located in the mechanical room. Pumps and supporting distribution system equipment for both systems are located in the mechanical room.

19.2.7 Waste Systems

The waste management area includes shielded enclosures for tanks collecting liquid waste and containers used to stage solid wastes generated by the other process systems. Liquid waste is mixed with a sorbent (or solidification agent) material in a HIC that is stored and eventually loaded into a shielded waste transport cask. The solid waste is size-reduced, placed in a drum, and encapsulated by adding a cement material. The drum is then closed and loaded into a shielded waste transport cask.

There is no solid or liquid waste disposal at the RPF site. Air effluents are discussed in Section 19.4.2.1.

19.2.7.1 Process System Liquid Wastes

Where practicable, liquid wastes are condensed and/or treated or recycled to reduce the environmental impacts associated with disposal. The liquid waste streams generated during the processing operations are handled with the aqueous waste-handling system discussed in Section 19.2.7.3.1. The individual liquid wastes generated during processing are summarized in Table 19-12.

Table 19-12. Liquid Waste Produced Annually from the Radioisotope Production Facility

Process	Annual waste	
	L	gal
[a]Target fabrication	45,000	11,890
[a]Target disassembly and dissolution	1,500	396
[a]Mo recovery and purification system	5,800	1,532
[a]Uranium recovery/recycle system	~1,120,000	295,873
Waste management	[b]	[b]
Laboratory facilities	2,000	530
Facility support	2,000	530

[a] Annual waste transferred to waste processes for concentration and solidification. These numbers do not account for planned process recycle.
[b] Wastes processed do not produce liquid waste other than small quantities of specialty wastes.

19.2.7.2 Process System Solid Waste

Where practicable, solid wastes are condensed and/or packaged to reduce the environmental impacts associated with disposal. The individual solid waste streams generated during the processes are summarized in Table 19-13.

Table 19-13. Solid Waste Produced at the Radioisotope Production Facility

Process	Components	Annual waste
Target fabrication	[a]NA	NA
[b]Target disassembly and dissolution	Target cladding materials from disassembly	1,100 L (290 gal)
[b]Mo recovery and purification	Exchange resins and other solid waste	20 L (5 gal)
[a]Uranium recovery and recycle	Exchange resin and media	~1,350 L (~360 gal)
[c]Waste management	Solid wastes encapsulated in cement	8,000 L (2,113 gal)
	High-dose solidified liquids	200,000 L (52,834 gal)
	Low-dose solidified liquids	150,000 L (39,625 gal)
Laboratory facilities	Municipal waste (e.g., chemicals) Potentially contaminated laboratory waste (e.g., sample vials and containers)	4,000 L (1,056 gal)
Facility support	Municipal waste (e.g., paper)	26,000 L (6,868 gal)
	Potentially contaminated waste (e.g., decontamination materials, PPE)	40,000 L (10,566 gal)

[a] Solid waste generated during target fabrication is anticipated to be decontaminated and free-released.
[b] Transferred to waste processing system for final disposition.
[c] The waste quantities current bounding estimates. Optimization of waste processing should reduce the volume of liquid waste generation.

NA = not applicable. PPE = personal protective equipment.

19.2.7.3 Waste Handling Process Systems

Solid and liquid waste generated by the other system operations discussed in Section 19.2.3.1.5 is processed by the waste handling process system. The waste handling process consists of three major subsystems:

- Liquid waste handling and disposal
- Solid waste handling and disposal
- Specialty waste handling and disposal

19.2.7.3.1 Liquid Waste Handling and Disposal System

The liquid waste handling system includes two subsystems: high-dose liquid waste solidification, and low-dose liquid waste solidification.

- **High-dose liquid waste solidification** – Accumulation tanks provide the needed handling capacity to match the volume of wastewater generated by the upstream processes. Caustic solution is added as needed to neutralize the excess acidity. The liquid is forwarded to a package concentrator in which water is evaporated from the high-dose liquid, condensed, and directed to a condensate holding tank. The concentrated high-dose liquid is directed to a concentrate holding tank.

  From the concentrate tank, the high-dose liquid is metered into a specialty inline mixer that melds together the high-dose liquid and a powder solidification agent (sorbent or solidification agent). A vibratory motor ensures that the mixture falls from the inline mixer into a HIC. With time, the mixture solidifies. The filled HIC is moved via remote equipment to one of several decay stations where the waste is held for several months. During that time, the short-lived radioisotopes in the waste that cause the container to register a very high dose rate decay to much lower levels. Afterward, the HIC is moved into a transport cask on a trailer. Cask operational steps are completed prior to shipment offsite for disposal.

- **Low-dose liquid waste solidification** – Accumulation tanks provide the needed handling capacity to match the volume of wastewater generated by the upstream processes. Condensates are held in a storage/recycling tank that provides make-up water to the LEU recovery process. Excess condensate, along with all the other low-dose liquid, is forwarded to a staging tank. In this heated tank, the liquid is held at elevated temperatures, and high rates of ventilation air pass through the tank. The heated tank contents, plus the high ventilation, cause a significant amount of the water to evaporate from the low-dose liquid.

  The excess low-dose liquid is then metered into a specialty inline mixer that melds the liquid and a powder solidification agent together. A vibratory motor ensures that the mixture falls from the inline mixer into a waste container. With time, the mixture will solidify. The waste container is then shipped for disposal offsite.

19.2.7.3.2 Solid Waste Handling and Disposal System

The solid waste disposal system includes areas for collection, size reduction, and staging of solid wastes. The solids are placed in a 208 L (55-gal) waste drum and encapsulated by adding a cement material to fill voids remaining within the drum. The drum is then loaded in a cask for transfer to a disposal site. The radioactive solid wastes have been identified and include:

- Hardware from target disassembly
- Resins and exchange media from the Mo recovery and purification process
- Resins from the uranium recovery and recycle process

- Low-dose solid waste from the hot cell and support areas
- Slightly contaminated hardware (low levels of LEU) from the target fabrication area
- Instruments, connectors, jumpers, and other hardware

Solid waste encapsulation – High-dose solid wastes are remotely moved in the hot cell to a staging area in the waste handling facility area. Size-reduction and handling tools are envisioned to place the wastes into a disposal container. Nominally of 454 L (120-gal) capacity, the container holds four weeks of wastes generated from the process. When practicable, the accumulated wastes are encapsulated with a fluid cement. The material solidifies and provides the needed stabilization to meet disposal criteria. The filled container is remotely moved to a transport cask via a shielded loading cask. The appropriate cask operational steps are completed prior to shipment for disposal offsite.

Support system waste – Spent filters containing suspended solids from dissolver solutions are disposed as solid waste. The number of filters to be disposed has not been determined, but is expected to be no more than one per batch of targets. Empty target hardware containing trace contamination is disposed as solid waste.

19.2.7.3.3 Specialty Waste Handling and Disposal System

A specialty waste disposal system addresses small quantities of unique wastes generated by other processes. A reclamation process is included to recycle trichloroethylene from waste liquid. Specialty wastes are assumed to be shipped offsite for treatment and disposal. These wastes include:

- Used silicone oil
- Solvent waste
- Facility maintenance fluids (e.g., paints, lubricants)
- Spent batteries, spent fluorescent lighting tubes, and others
- Personal protective equipment (PPE) waste
- Laboratory waste for expired chemicals and expired radioactive sources

19.2.7.4 Construction Waste

During construction, efforts are made to minimize the environmental impact. Erosion, sedimentation, dust, smoke, noise, unsightly landscape, and waste disposal are controlled to practical levels and applicable regulatory limits. The wastes generated during site preparation and construction are varied, depending on the activities in progress. The bulk of the waste consists of nonhazardous materials such as packing materials, paper, and scrap lumber. These wastes are transported offsite to an approved landfill. These wastes that are generated are handled by approved methods and shipped offsite to approved disposal sites.

Best management practices (BMP) are used during construction to minimize the possibility of spills of hazardous substances, minimize environmental impacts of any spills, and ensure prompt and appropriate remediation.

19.2.7.5 Recycling and Reclamation

With a continued focus on managing economic and environmental cost and impacts, proposed RPF processes involve recycling throughout each step. The following subsections summarize the systems designated for specific recycling efforts. Paper, plastic, and other administrative supplies are also recycled as appropriate.

Solvent recovery – Forming of the LEU target material requires use of a common solvent (trichloroethylene). Used solvent falls under the F-code type of waste disposal, making the solvent a potentially costly disposal and treatment path. Because most solvents are not spent after their use, the solvent could be recovered for reuse to minimize the final waste volume that is sent offsite for treatment and disposal. Standard industrial units are available for solvent reclamation. The used solvent from the process is loaded into the unit and vaporized, and then condensed to yield reclaimed solvent ready for reuse. The residue is contained in a concentrated solvent heel that is sent offsite for treatment and disposal.

Uranium – A major portion of hot cell operations is to recover and recycle uranium. This approach significantly reduces the amount of waste that has to be disposed. Section 19.2.3.1.4 discusses the recovery and recycle of uranium. The target fabrication process also recycles the uranium scrap generated during processing.

Process water – The waste management system segregates and recycles process condensates to be used back in the processes as make-up and flush water. The recycle will reduce the low level waste generated by about 50 percent.

19.2.7.5.1 Direct Radiation Sources Stored Onsite the Radioisotope Production Facility

Direct radiation sources stored onsite – The waste listed in Table 19-14 is stored onsite for a period of time to allow decay before the waste is shipped offsite. The frequency of shipments for each type of waste is also provided in Table 19-14.

19.2.7.5.2 Direct Radiation Sources Stored at Nearby Operating Facilities

Facilities that handle and store radioactive materials in the area of the RPF are discussed in Section 19.2.2.5 and 19.3.8.2.2.

19.2.7.5.3 Pollution Prevention and Waste Minimization Program

Pollution prevention and waste minimization activities promote practices that maximize beneficial effects and minimize harmful effects on the surrounding environment. These activities include efforts to prevent pollution by minimizing the kinds and amounts of waste generated. The RPF will have a pollution prevention and waste minimization program that includes the following:

- Employee training and education
- Waste minimization and recycling programs for various phases (e.g., construction, operations)
- Recognition of employees for improved environmental conditions
- Responsibilities and requirements to consider in day-to-day activities

Pollution prevention involves source reduction, or preventing pollution at its source, before it is generated. Source reduction includes any practice that reduces the quantity and/or toxicity of pollutants entering a waste stream prior to recycling, treatment, or disposal. Examples include equipment or technology modifications, substitution of less toxic raw materials, and improvements in work practices, maintenance, worker training, and inventory control.

Waste minimization refers to the use of source reduction and/or environmentally sound recycling methods prior to energy recovery, treatment, or disposal of wastes. Waste minimization does not include waste treatment (i.e., any process designed to change the physical, chemical, or biological composition of waste streams).

19.2.8 Storage, Treatment, and Transportation of Radioactive and Nonradioactive Materials, including Fuel, Waste, Radioisotopes, and Any Other Materials

19.2.8.1 Storage and Treatment

Storage, handling, and treatment of materials, product, and wastes are performed in a time-sensitive manner, in assigned areas, and using approved waste management, security, health and safety, and shielding procedures. This approach ensures that appropriate volume reduction is achieved, while minimizing the risk of exposure to the worker, public, or the environment.

19.2.8.1.1 Storage of Chemicals and Supplies

A chemical management plan, product handling plan, or radioactive materials management plan is developed to ensure that:

- Noncompatible chemicals are separated
- Flammable chemicals/items are stored in a flameproof cabinet, as applicable
- Oxidizers are stored separate from flammable chemicals and reducers
- Radioactive sources or supplies are stored in locked cabinets/areas such that any potential exposure is kept as low as reasonably achievable (ALARA)
- New feed and recycled LEU is stored in an appropriate configuration and in a locked storage area until needed in the process

19.2.8.1.2 Treatment and Temporary Storage of Waste Onsite

Treatment and temporary storage of radioactive and mixed wastes are performed predominantly onsite within the RPF.

- Liquid waste that is not recycled/reused is eventually concentrated and mixed with sorbent material in the waste management area.
- High-dose material, solidified (if necessary) and encapsulated, is held in a shielded enclosure in the RFP, interim-stored for radioactive decay to meet shipping and disposal requirements, and then loaded into a cask and shipped to a disposal site.
- Low-dose stream, mixed with sorbent, is placed in drums, moved to the external waste management building for staging, and then shipped to a disposal site.
- Solid waste is typically size-reduced as necessary, placed in containers, encapsulated, moved to the external waste management building for staging, and then shipped to a disposal site.
- Target fabrication solvent reclamation area allows reuse of key materials. Any spent solvent is treated and packaged for shipment to a treatment and disposal facility.
- Other industrial or commercial wastes (e.g., chemicals, paper products) will be managed in an environmentally and economically responsible manner. Recycling programs are used as needed.

19.2.8.1.3 Capacity of Onsite Radioisotope Production Facility Materials Storage

Materials needed for LEU target fabrication (e.g., solvents, silicon oil, cladding) are received and stored. Finished LEU targets are interim-stored until shipped to a university reactor system for irradiation.

Because of the short half-life of ^{99}Mo, there is almost no accumulation of ^{99}Mo product. The ^{99}Mo product is shipped out twice per week. Chemicals and process supplies are stored according to the chemical management plan or facility procedures to ensure the lowest risk of exposure/contamination or accidental release.

19.2.8.2 Transportation of Material

The transport of radioactive materials and waste and other hazardous materials associated with the RPF must comply with applicable NRC and DOT regulations. DOT specifies the requirements for marking, labeling, placarding, providing emergency response information, and training hazardous material transport personnel in 49 CFR 172. Specific packaging requirements for radioactive materials are provided in 49 CFR 173, Subpart I, "Class 7 (Radioactive) Materials." These requirements invoke the NRC packaging requirements for radioactive material per 10 CFR 71, "Packaging and Transportation of Radioactive Material." The DOT requirements for truck transportation of radioactive and other hazardous materials are specified in 49 CFR 177 and 49 CFR 397, "Transportation of Hazardous Materials; Driving and Parking Rules." Requirements affecting the shipment of ^{99}Mo are specified in 49 CFR 175 and are the responsibility of the air carrier chosen to transport the ^{99}Mo product.

19.2.8.2.1 Packaging Systems

The majority of the radioactive components being shipped to and from the RPF require special container systems to ensure that protection of the public and the environment is achieved. Each of these containers is designed to meet certain NRC and DOT standards. Although the irradiated targets are not identified as a spent nuclear fuel shipment, NWMI will also use the guidance provided in NUREG-0561, *Physical Protection of Shipments of Irradiated Reactor Fuel*.

The primary radioactive materials and wastes that require a specialty container or cask are as follows:

- **Fresh LEU** – Fresh LEU will be shipped from the DOE Y-12 Program Office in Oak Ridge, Tennessee to the NWMI RPF using an ES-3100 Package (Certificate of Compliance No. 9315) (NRC, 2005). The DOE Y-12 Program Office routinely uses the package, which is currently licensed for the NWMI feed materials. DOE has a dedicated QA program for package use and maintenance, and all procedures are in a mature state.

  The ES-3100 package is a cylindrical container that is approximately 110 centimeter (cm) (43 inches [in.]) in overall height and 49 cm (19 in.) in overall diameter, and has an outer drum assembly and an inner containment vessel. The containment vessel is placed inside the drum and surrounded by a cement-based borated neutron absorber, Catalog 277-4. The purpose of the ES-3100 is to transport bulk high enriched or LEU uranium in various forms.

- **Unirradiated targets** – Unirradiated targets will be shipped using the ES-3100 or similar package, as described above. Unirradiated targets will be shipped to the network of university research reactors.

- **Irradiated targets** – Irradiated targets will be received from the university reactors in a BEA Research Reactor cask or similar (Certificate of Compliance No. 9341) (INL, 2011). Within the cask, the irradiated targets are contained in basket structures that are specifically designed for NWMI's target and provide for optimum heat rejection and criticality control.

The BEA Research Reactor cask is a truck-mounted cask designed for the shipment of research reactor fuel. The cask fully loaded weighs approximately 14,515 kg (32,000 lb). The overall height of the package with impact limiters is 3.04 m (119.5 in.). The outer diameter of the body is 0.97 m (38 in.). The outer diameter of the impact limiters is 1.52 m (60 in.), and each weighs approximately 1,043 kg (2,300 lb). The cask body is shielded with 20.3 cm (8 in.) equivalency of lead. The inner cavity of the BEA Research Reactor cask is 0.46 m (16 in.) in diameter and 1.70 m (67 in.) in height.

The cask currently is designed to hold four different baskets for the different fuel families. NWMI will need to obtain a license amendment for transport of irradiated targets in the BEA Research Reactor cask.

- **^{99}Mo product** – The ^{99}Mo product will be placed into a Medical Isotope Depleted Uranium Shielded (MIDUS) Type B(U) container (Certificate of Compliance USA/9320/B(U)-96) (NRC, 2008a) or similar. The MIDUS container is currently used by U.S. and other radiopharmaceutical ^{99}Mo producers worldwide.
- **Radioactive waste** – High-dose radioactive waste will be loaded in HICs and shipped in a cask, such as the Model 10-160B cask (ES, 2012). This type of cask is a lead-shielded carbon steel cask with a double-lid, bolted closure and is top-loaded. The cask is shipped vertically, with removable top and bottom polyurethane foam-filled impact limiters. Low-dose radioactive waste will be loaded into 208 L (55-gal) waste drums.
- **Contact-handled waste** – Standard industrial waste drums or other appropriate containers will be used to dispose of contact-handled radioactive waste. Contact-handled waste is defined as waste that is less than 2 millisievert (mSv)/hr (200 millirem per hour [mrem/hr]) on contact and 0.1 mSv/hr (10 mrem/hr) at 1 m (3.3 ft). These containers must be handled according to the facility radioactive waste management plan to ensure that dose is kept ALARA. These waste containers generally do not require shielded casks or special shielding for transportation purposes.

19.2.8.2.2 Estimated Type and Quantity of Radioactive Materials and Wastes

The estimated type and quantity of radioactive materials and wastes, number of shipments, shipment type, distance, and destination are summarized in Table 19-14. These distances and times may vary depending on available shipping routes or weather conditions. The number of shipments per year may also vary depending on what reactor is used for irradiation.

Table 19-14. Summary of Radioactive Materials and Wastes Required or Generated at the Radioisotope Production Facility for Ongoing Operations

Description	Matrix	Qty/year	Package type	Number of shipments/year	To/from	Distance km (mi)
Fresh LEU Annually Initial need Operation [Proprietary Information] Operation [Proprietary Information] (U_3O_8 or metal)	Solid	[Proprietary Information] [c] [Proprietary Information] [d] [Proprietary Information] [e] [Proprietary Information]	ES-3100 cask	2 (operations annual average)	From DOE Y-12 (Oak Ridge, Tennessee)	953 (592)
Unirradiated LEU targets	Solid	[Proprietary Information]	[a]ES-3100 cask	26	To MURR	9.6 (6)
	Solid	[Proprietary Information]	[a]ES-3100 cask	8	To OSTR	3,320 (2,063)
	Solid	[Proprietary Information]	[a]ES-3100 cask	8	To third reactor	[Proprietary Information]
Irradiated LEU targets	Solid	[Proprietary Information]	[a]BRR cask	104	From MURR	9.6 (6)
	Solid	[Proprietary Information]	[a]BRR cask	16	From OSTR	3,320 (2,063)
	Solid	[Proprietary Information]	[a]BRR cask	16	From third reactor	[Proprietary Information]
^{99}Mo product	Liquid	48 L (12.7 gal)	[a]MIDUS cask	52	To Hazelwood, Missouri	181 (113)
	Liquid	48 L (12.7 gal)	[a]MIDUS cask	52	To Billerica, Massachusetts	[b]63 (39)
Spent LEU	Solid	[Proprietary Information]	ES-3100 cask	2	To SRS	1,345 (836)
Radioactive waste (high- and low-dose radioactive waste)	Solid	540,000 kg (1,190,500 lb)	[a]10-160B	200	To Waste Control Specialists (Andrews, TX)	1,469 (913)

[a] Package type identified can be changed to another similar package.
[b] Only includes road miles traveled.
[c] LEU needed for hot commissioning and initial RPF startup.
[d] LEU needed in Operation (Proprietary Information] for addition of second reactor.
[e] LEU needed in Operation [Proprietary Information] for addition of third reactor.

BRR = BEA Research Reactor.
DOE = U.S. Department of Energy.
LEU = low-enriched uranium.
MIDUS = Medical Isotope Depleted Uranium Shielded.
OSTR = Oregon State University TRIGA Reactor.
SRS = Savannah River Site.
MURR = University of Missouri Research Reactor.

19.3 AFFECTED ENVIRONMENT

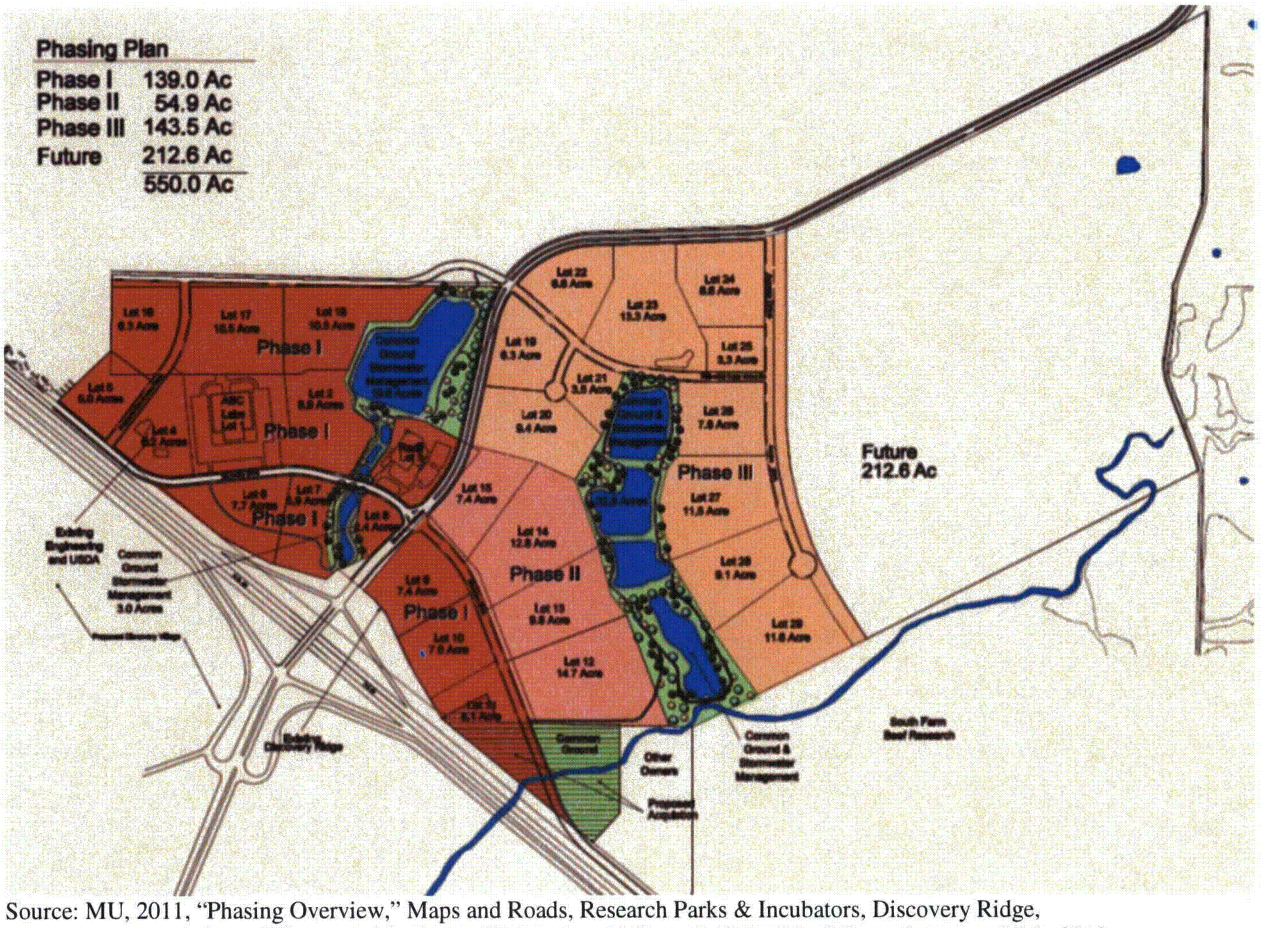
19.3.1 Land Use and Visual Resources

19.3.1.1 Land Use

This section characterizes land use associated with the proposed RPF. The facility is proposed to be sited at Discovery Ridge, located on property owned by MU. The university occupies a 505 ha (1,250-acre) campus and is located 4.8 km (3 mi) southeast of Discover Ridge, which is just south of downtown Columbia. Land uses are within an 8 km (5-mi) region of influence (ROI). The ROI is the geographic area associated with each resource that could potentially be affected by the proposed action. The land use for the site was analyzed using data from the National Land Cover Database (Fry et al., 2011).

19.3.1.1.1 Site – Description of the Proposed Property

The RPF would be located in Lot 15 of the Discover Ridge Phase II section. The Phase II area is 22.2 ha (54.9 acres) and, as shown in Figure 19-14, is bounded by the Phase III area to the north, Discovery Parkway and the Phase I section to the west/northwest, Discovery Drive to the south/southwest, Lot 14 and stormwater management areas to the east, and private property to the south.



Source: MU, 2011, "Phasing Overview," Maps and Roads, Research Parks & Incubators, Discovery Ridge, www.umsystem.edu/umrpi/discoveryridge/maps, University of Missouri, Columbia, Missouri, accessed July 2013.

Figure 19-14. Layout of Discovery Ridge Research Park Showing Lot 15, the Proposed Radioisotope Production Facility Site

Lot 15 is 3.0 ha (7.4 acres) and contains no existing structures (MU, 2011). Currently, the 46.1 ha (114-acre) research park is being developed under the guidance of the *Discovery Ridge Master Plan and Protective Covenants* (MU, 2009). Figure 19-6 shows the site boundaries and proposed structures. Dimensions of the RPF are approximately 106.7 x 56.4 m (350 x 185 ft) by 19.8 m (65 ft) in height abovegrade (maximum). The facility would occupy a rectangular area approximately 213 x 91 m (700 x 300 ft) at the outer perimeter and cover approximately 1.95 ha (4.8 acres) on Lot 15. The restricted area would be the area inside the fence surrounding the facility. The unrestricted area would be the area outside the fence surrounding the main building.

19.3.1.1.2 Major Population Centers and Infrastructure – Local Setting

The proposed site resides entirely within the Columbia city limits and is approximately 200 km (124 mi) south of St. Louis (population 319,294); 203 km (126 mi) east of Kansas City (population 459,787); and 45 km (28 mi) north of Jefferson City (population 43,088) (USCB, 2010a). The proposed site lies in Boone County (population 162,642) (USCB, 2010b).

19.3.1.1.3 Transportation Infrastructure

Section 19.3.7 provides a description of the regional air, road, and rail transportation systems.

The Missouri River is one of the largest river systems in the U.S. and the largest river in Boone County. The river originates in south central Montana and generally flows in an easterly and southeasterly direction before entering the Mississippi River in eastern Missouri, a length of about 4,345 km (2,700 mi). The river lies approximately 11.7 km (7.3 mi) to the west of the proposed RPF and forms the southwestern border of Boone County. The Missouri River is the only river system in Boone County large enough for commercial navigation; however, there are no ports that directly service Columbia (MU, 2006a).

19.3.1.1.4 Local Setting

Discovery Ridge lies at the crossroads of U.S. Highway 63 and Gans Road, which is near the MU main campus, U.S. Interstate 70, Columbia Regional Airport, University Hospital, Columbia Regional Hospital, downtown Columbia, and Jefferson City. Discovery Ridge, when fully developed, will occupy 223 ha (550 acres) and is bounded by East Sugar Grove Road to the north, South Rolling Hills Road to the east, U.S. Highway 63 to the south, and Sunset Mobile Home Park to the west. Perry Phillips Park (57 ha [140 acres] and a 16 ha [40-acre] lake) and the Frank G. Nifong Memorial Park (23 ha [58 acres]) are located nearby to the west. The MU Bradford Research and Extension Center (a 239 ha [591-acre] research farm) lies to the north of Discovery Ridge. Figure 19-5 shows the local setting for the proposed RPF site.

19.3.1.1.5 Regional Setting

The ROI is defined as the area within an 8 km (5-mi) radius of the proposed facility centerpoint (Figure 19-5). The ROI includes nearly half of Columbia and the entire MU area. The MU student population, when in full session, is approximately 34,658 (MU, 2013).

Existing land uses in a concentric ring pattern around the RPF can generally be described as follows (MU, 2006a):

- **0–1 km (0–0.6 mi)** – There is very little residential development within the immediate area of the proposed RPF. Most of the land is owned and operated by MU. Recreational areas include a golf course to the west and a park to the south. Three MU sports venues are located within this area: Memorial Stadium/Faurot Field, Mizzou Arena, and Hearnes Center.
- **1–2 km (0.6–1.3 mi)** – Residential areas are located north, northwest, and south of the proposed RPF site. A shopping center, business district, two hospitals, and a large portion of the MU main campus are located within this area. With the exception of a small area to the southeast, there is no room for any substantial residential or nonresidential (industrial, commercial, or business) development.
- **2–4 km (1.3–2.5 mi)** – The major residential areas are located in the northern half of the ROI and to the southwest. A shopping center, business district, two hospitals, two colleges, three high schools, three middle/junior high schools, and nine elementary schools are located in this area. Recreational areas include two golf courses and eight parks. The downtown area of Columbia, comprised mainly of government offices and retail, commercial, and business uses, is located to the northeast. Development is expected to continue within this area, probably to the south of the proposed RPF.
- **4–6 km (2.5–3.7 mi)** – Most residential development is within the northern half of the ROI. Three shopping centers, two hospitals, one middle/junior high school, three elementary schools, and an industrial park are located in this area. Recreational areas include two golf courses and five parks. Substantial amounts of land exist for residential or nonresidential development.
- **6–8 km (3.7–5 mi)** – The only substantial residential development is northeast of the proposed RPF site. A shopping center, two middle/junior high schools, and four elementary schools are located in this area. Recreational areas include one park. Substantial amounts of land presently exist for residential or nonresidential development.

19.3.1.1.6 Land Use and Cover within the Regional Setting

There are 20,342 ha (50,265 acres) in the 8 km (5-mi) ROI surrounding the proposed RPF. According to the data from the U.S. Geological Survey (USGS) (Fry et al., 2011), approximately 25 percent of the land is developed (i.e., residential, commercial). Forest and pasture land are the next highest uses at 31 and 30 percent, respectively. Cultivated cropland follows next at 9 percent. The remaining land use types total less than 1 percent of each category and include barren land, evergreen forest, grassland/herbaceous, mixed forests, open water, scrub, and woody and emergent herbaceous wetlands.

Land use, as categorized by the USGS, is presented in Table 19-15. Figure 19-15 shows the distribution of these land uses within the ROI. Most developed lands lie to the northwest, while agricultural lands lie to the east and southeast. Deciduous forest is interspersed throughout the ROI.

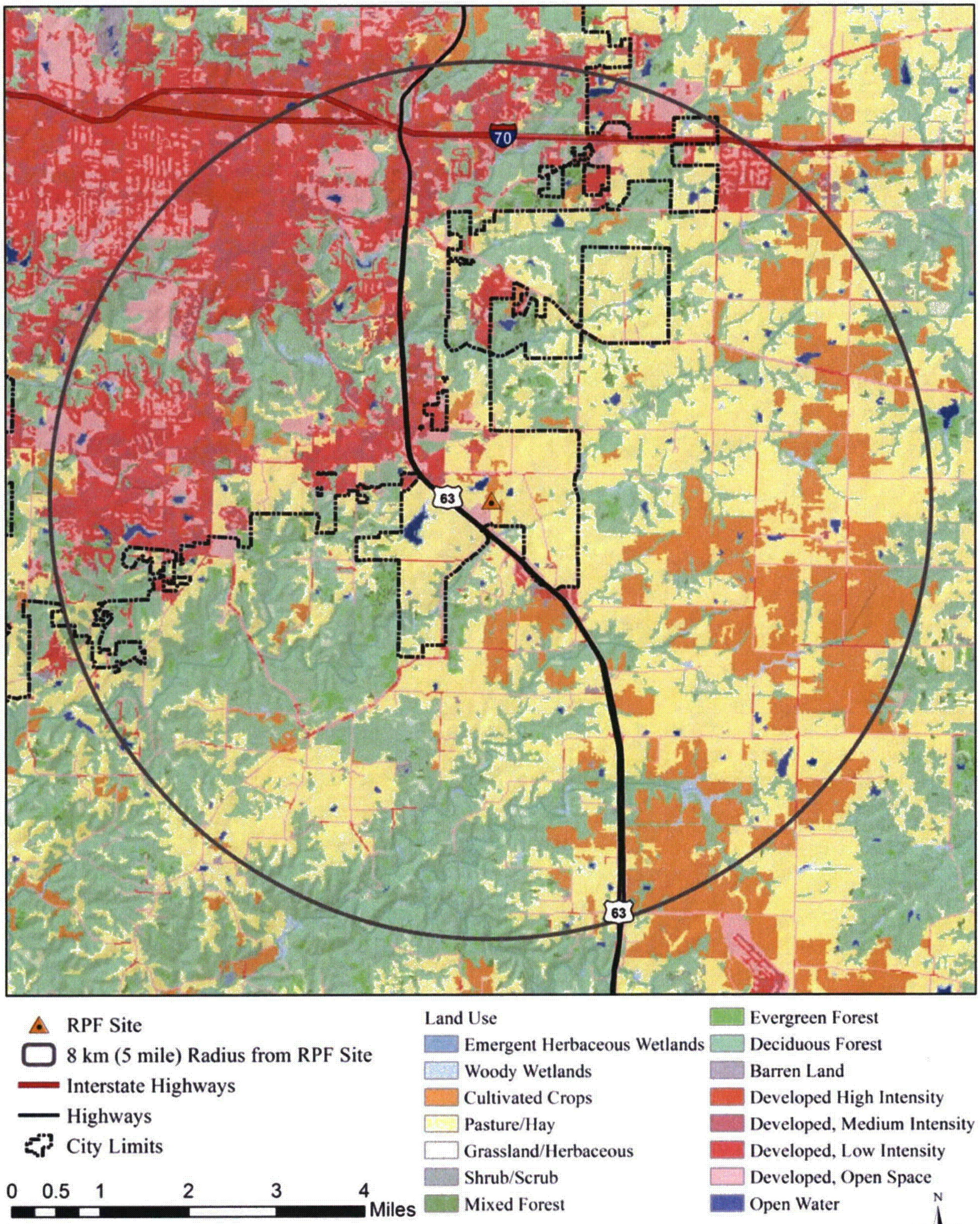
Table 19-15. U.S. Geological Survey Land Use Categories for the 8 km (5-mi) Region of Influence Surrounding the Proposed Radioisotope Production Facility

Description	Hectares	Acres	Percent
Barren land	16.19	93.66	0.19
Cultivated crops	1,877.38	4,639.11	9.23
Deciduous forest	6,365.64	15,729.81	31.29
Developed, high intensity	368.85	911.45	1.81
Developed, low intensity	1,892.74	4,677.06	9.30
Developed, medium intensity	1,120.87	2,769.74	5.51
Developed, open space	1,666.96	4,119.15	8.19
Emergent herbaceous wetlands	0.955	2.36	0.00
Evergreen forest	216.30	534.48	1.06
Grassland/herbaceous	139.60	344.96	0.69
Mixed forests	189.75	468.87	0.93
Open water	140.20	346.44	0.69
Pasture/hay	6,134.34	15,158.25	30.16
Scrub	43.31	107.02	0.21
Woody wetlands	146.95	363.13	0.72
Total Acres	**20,320.035**	**50,265.48**	**100.00**

Source: Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, and J. Wickham, 2011, "Completion of the 2006 National Land Cover Database for the Conterminous United States," Photogrammetric Engineering & Remote Sensing Journal, Volume 77(9):858-864, Bethesda, Maryland, 2001.

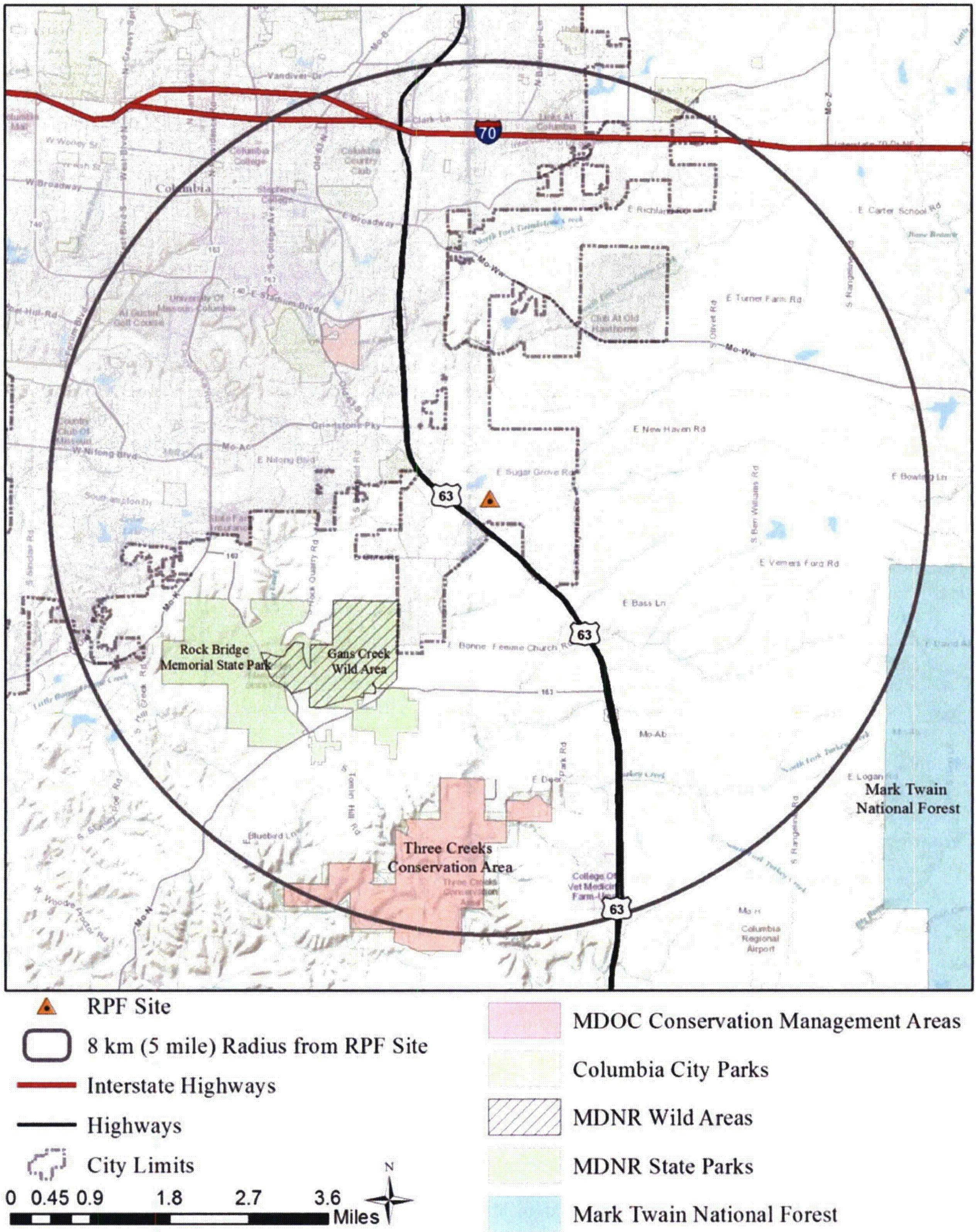
19.3.1.1.7 Special Land Uses

Special land uses within the ROI include public stewardship lands and prime farmlands (farmland is discussed in Section 19.3.1.1.10). There is no Federal land held in trust for American Indian tribes within the ROI. Approximately 7 percent (1427 ha [3,527 acres]) of the land is public stewardship lands (e.g., parks, conservation areas) that primarily lie southwest of the proposed RPF. There are no military reservations or Federally designated wild and scenic rivers, national parks, national forests, or coastal zone areas within the ROI. Figure 19-16 shows the location and extent of the special land uses.



Land Use
Citation: USGS 2006 *National Land Cover Database CONUS Land Cover* [digital data]: http://www.mrlc.gov

Figure 19-15. Land Use and Cover within the 8 km (5 mi) Region of Influence of the Proposed Radioisotope Production Facility Site



Special Land Use

Figure 19-16. Special Land Use within the Region of Influence of the Proposed Radioisotope Production Facility Site

19.3.1.1.8 Applicable Land Use Plans and Guidance

Discovery Ridge was developed under Section 172.273 of the Missouri Revised Statutes, which provided that "the Curators of the University of Missouri may establish research, development, and office park projects in order to promote cooperative relationships and to provide for shared resources between private individuals, companies and corporations, and the University of Missouri, for the advancement of the University in carrying out its educational mission and such projects are declared to be in furtherance of the purposes of the University."

The *Discovery Ridge Master Plan and Protective Covenants* (MU, 2009) is the applicable land use guidance for the research park. Discovery Ridge is zoned commercial in the A-1 district (City of Columbia, 2012a), under the Section 29-18 provision, Board of Adjustment (City of Columbia, 2012b). The Columbia Code (Section 29-18) has height restriction for A-1 of 10.7 m (35 ft).

Missouri Revised Statute, Section 172.273, exempts university research parks, including Discovery Ridge, from local land development regulations. This allows MU to develop Discovery Ridge to its own master plan and to include non-agriculture-related structures with sizes in excess of the A-1 zoning requirements, provided MU gives Columbia courtesy review of the plan and design drawings and addresses the city's comments and concerns. The master plan and covenants for the development do not specify height restrictions.

"Columbia Imagined, The Plan for How We Live & Grow" is the current comprehensive plan for Columbia (City of Columbia, 2013c), and the *Boone County Master Plan* (Boone County, 1996) guides development of lands outside of city limits but within the county.

19.3.1.1.9 Future Development

Only a few tenants currently occupy Discovery Ridge. According to the master plan and covenants (MU, 2009), the future and growth of Discovery Ridge itself will be market-driven. Future tenants are expected to be businesses that are compatible and synergistic with the research programs at MU. Tenants obtain a ground lease from the university and construct their own facilities. Facilities are designed to conform to uniform building codes and design standards listed in the "Declaration of Covenants, Conditions, Restrictions, and Easements for Discovery Ridge" (MU, 2009). Expansion and/or property acquisition beyond the 223 ha (550 acres) currently defining Discovery Ridge is possible in the future and requires approval by the MU Board of Curators.

Nearby future development includes a city park and a large commercial and residential development that is planned for the west side of U.S. Highway 63, adjacent to the overpass that provides access to the Discovery Ridge Parkway. According to Columbia (2013c)," the city's planning staff is studying steering employment to developing office and industrial centers, which includes Discovery Ridge, in response to citizen goals and objectives offered through the city's comprehensive plan planning process. This approach is being considered as the city continues to study and identify anticipated future economic growth.

19.3.1.1.10 Agricultural Resources and Facilities

The principal agricultural products of Boone County, as estimated by the U.S. Department of Agriculture (USDA), are corn for grain, corn silage for greenchop, spring/winter wheat for grain, and oats and barley for grain (USDA, 2007). Livestock also has significant importance because much of the land is not suited for row crops.

Agriculture resources nearest to the RPF site are associated with MU and include the following:

- **South Farm** – A 588 ha (1,452-acre) complex that supports research, outreach, and teaching missions of animal science, plant science, veterinary science, biology, botany, and other disciplines. The farm is home to the Swine Research Complex, Beef Research and Teaching Farm, Turf Center, USDA Agricultural Research Service, and Horse Farm. The complex also supports research and demonstration projects in entomology, poultry, and maize genetics. The Missouri Foundation Seed Program uses South Farm to increase the sales of newly developed seed varieties to dealers. Hands-on teaching is provided to more than 1,500 students annually.
- **Jefferson Farm and Gardens** – A 27 ha (67-acre) educational facility that provides information on farming, gardening, and conservation.
- **Bradford Research and Extension Center** – A 239 ha (591-acre) research farm that provides land, equipment, and facilities to assist university and USDA scientists and extension personnel in performing research in crop, soils, entomology, pathology, turf, and other disciplines on more than 25,000 plots.

A number of privately owned farms also lie in the surrounding area.

19.3.1.1.11 Mineral Resources

According to the EPA Western Ecology Division's Ecoregions of Missouri (Chapman et al., 2002), the proposed RPF site is part of the Claypan Prairie Level IV ecoregion, which is located within the Central Irregular Plains Level III ecoregion.

Well-developed claypan soils on glacial till typify the Claypan Prairie ecoregion. This region has a more level, gently rolling topography than surrounding regions. Expansive cropland and pastureland, with an emphasis on livestock production, is common. The potential natural vegetation is tall grass prairie with less woodland than surrounding regions. Streams run generally west to east, draining into the Mississippi River, in contrast to the northwest-to-southeast drainage of ecoregions to the west.

The Claypan Prairie ecoregion was glaciated in the pre-Illinoian time period. The continental drift, largely derived from limestone and shale, is composed of clay with a high percentage of rock fragments. Groundwater tends to be saline, unlike the freshwater of ecoregions to the southeast. The mix of land-use activities includes mining operations of high-sulfur bituminous coal. Although, historically, mining was more widespread, a few new mines continue to open. The disturbance of these coal strata in southern Iowa, areas of northern and southwestern Missouri, and southeastern Kansas has degraded water quality and affected aquatic biota (Chapman et al., 2002).

19.3.1.2 Visual Resources

A viewshed is an area of land, water, sky and associated environmental elements that is visible to the human eye from a fixed vantage point. Viewsheds often contain relatively large expanses of natural areas such as watersheds, unfragmented habitat, and unobstructed views. Viewsheds typically are spaces that are readily visible from public areas such as from roadways, parks, or high-rise buildings. The beauty of these areas contributes to the short-term and long-term quality of life for the people and communities who experience them. In urban areas, appealing viewsheds attract people and businesses and are associated with higher property values.

Visual resource management is the identification of visual values and establishment of objectives for managing those values. NRC (2012a) identifies the Bureau of Land Management (BLM) Visual Resource Management System (BLM, 1986) as the method for rating the aesthetic/scenic quality of a proposed site.

The BLM process involves a scenic quality evaluation, sensitivity level analysis, and a delineation of distance zones. Based on these three factors, lands are categorized by their relative visual value, which provides the basis for considering these values and impacts during the planning process. The BLM process is considered the standard for visual resource management. In overview, the process involves the following steps:

- **Inventory** – An inventory provides written descriptions and photos of the views or open space of concern. The inventory may also include site information regarding distinguishing characteristics, parcel size, ownership, access points for best view, and potential threats to preservation.
- **Rating** – For each inventory item, a rating is assigned that considers such factors as scenic quality, sensitivity level, and distance zones. Based on the rating, lands are categorized into visual resource importance classes. The classifications typically range from most valued to least valued classes and assign value to the visual resource.
- **Protection level** – Levels provide the basis for considering visual values in the planning process. For example, during an environmental analysis, a project that is found to impact highly important visual resources might be redesigned, relocated, or resituated to lessen its impact.

The process of determining the affected environment for visual resources begins with a description of the visual setting and the regulatory requirements affecting the setting.

19.3.1.2.1 Description of the Visual Setting

Discovery Ridge is located on the edge of Columbia in a suburban/rural interface setting where farmland, parks, and natural areas are widespread and interspersed with residential dwellings, community and transportation infrastructure, and business establishments. Discovery Ridge is minimally developed at this time.

A Phase I environmental site assessment included a cursory visual reconnaissance and description of the area that included Lots 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18, and adjoining properties (Terracon, 2011a). The assessment describes the overall visual setting in which Lot 15 lies; the lot on which the proposed RPF would be located. All except Lot 5 are vacant; that lot is developed with a storage building. The ground is generally grass-covered, with portions of cultivated fields in the vicinity of Lot 16. The general topography slopes slightly to moderately downward toward the south and west (Terracon, 2011a). Table 19-16 presents information from the site assessment that describes the viewshed from Discovery Ridge boundaries.

Table 19-16. Discovery Ridge Viewshed

Direction	Objects discernible in the viewshed
North	Ed's Mobile Home Park and Sunset Mobile Home Park to the northwest, and farmland with University of Missouri storage buildings, farmland, and Sugar Grove Lane to the north and northeast
East	Farmland and buildings associated with the University of Missouri Beef Farm
South	Lenoir Street, a residential house, U.S. Highway 63, Ponderosa Drive, and farmland
West	Lenoir Street, U.S. Highway 63, Ponderosa Drive, and the Phillips Farm

Source: Terracon, 2011a, *Phase I Environmental Site Assessment Discovery Ridge Lots 2, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18*, Terracon Consultants, Inc., prepared for University of Missouri and Trabue, Hansen & Hinshaw, Inc., Terracon Project No. 09117701, March 23, 2011.

Photos were taken from the locations indicated on Figure 19-17 toward the proposed RPF in September 2013. Figure 19-18 through Figure 19-25 show the views. Most views are of undeveloped or minimally developed areas, with occasional trees, roads, power lines, and farmland.

Photopoint	Coordinates		Distance to Site (miles)	Bearing to Site
	Latitude	Longitude		
1	38.8832816	-92.257964	1.55	40°
2	38.8839205	-92.295636	1.56	321°
3	38.8984225	-92.279832	0.25	314°
4	38.8980107	-92.289108	0.72	289°
5	38.9009104	-92.302214	1.4	270°
6	38.9054502	-92.289945	0.8	244°
7	38.9123671	-92.257477	1.3	134°
8	38.9267775	-92.238096	2.72	135°

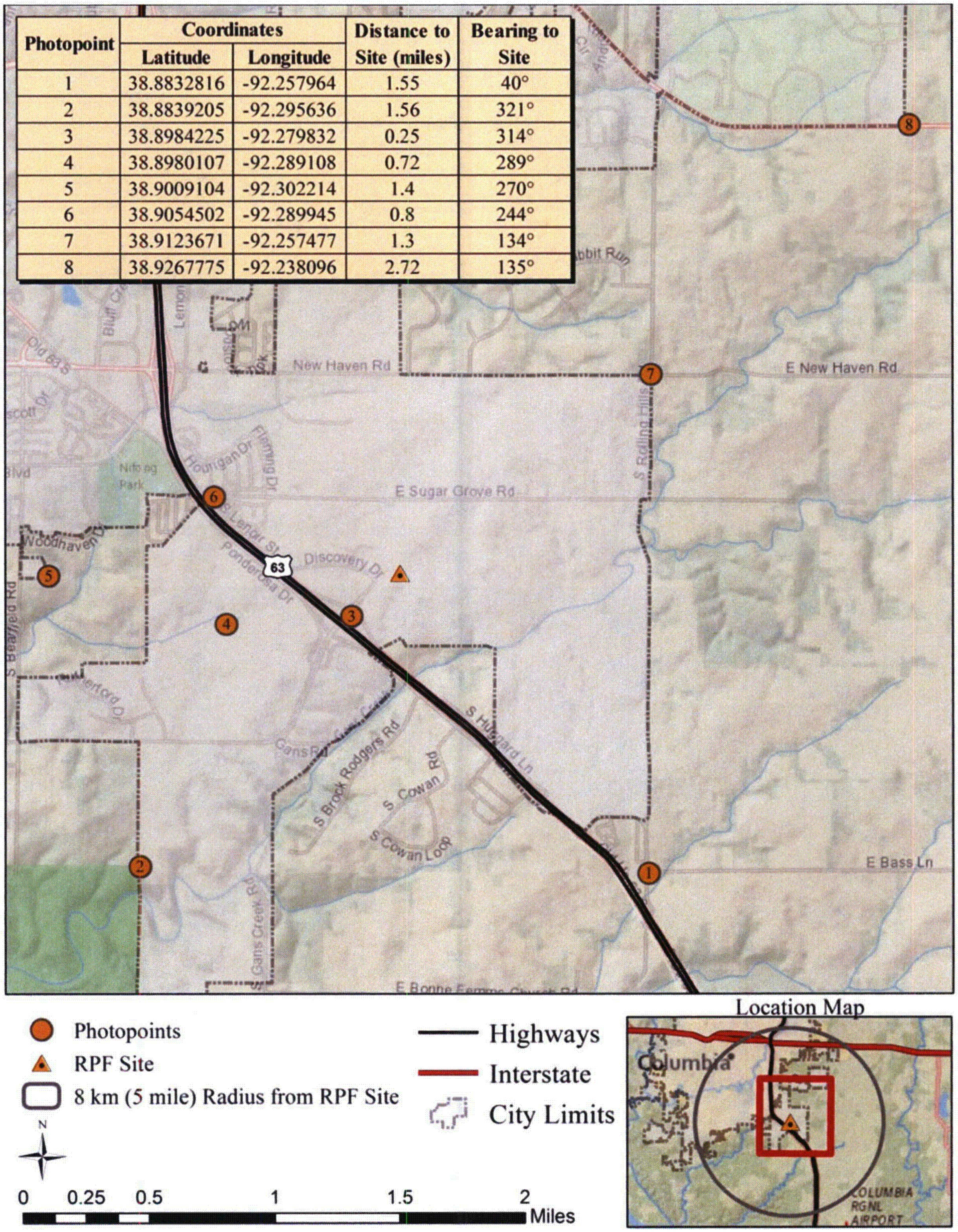


Figure 19-17. September 2013 Visual Reconnaissance Photo Locations

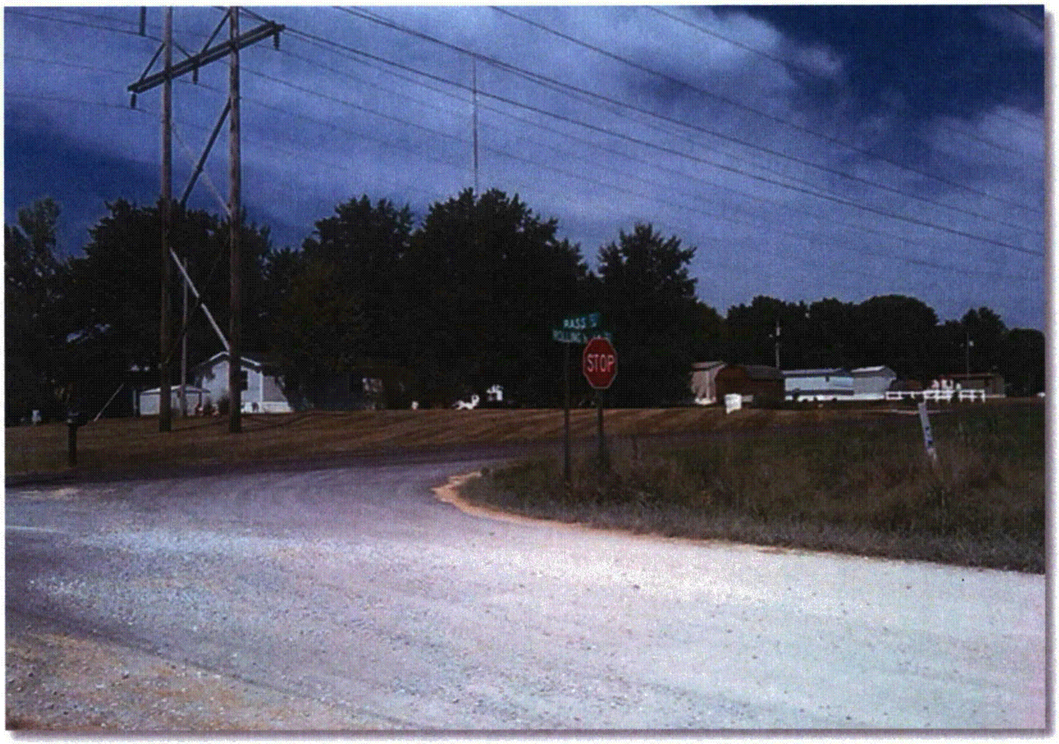


Figure 19-18. View of Proposed Radioisotope Production Facility Site from Intersection of Rolling Hills and Bass Roads, Photo Location #1

Figure 19-19. View of Proposed Radioisotope Production Facility Site from Gans Road, approximately 1.6 km (1 mi) North Photo Location #2

Figure 19-20. Direct View of Radioisotope Production Facility Site from Discovery Parkway near the Overpass, Photo Location #3

Figure 19-21. View of Radioisotope Production Facility Site from the North Edge of Perry Phillips Lake, Photo Location #4

Figure 19-22. View of Proposed Radioisotope Production Facility Site from Boys and Girls Town of Missouri, Photo Location #5

Figure 19-23. View of Proposed Radioisotope Production Facility Site from S. Lenoir and Roosevelt Avenue, Photo Location #6

Figure 19-24. View of Proposed Radioisotope Production Facility Site from Intersection of New Haven and Rolling Hills Roads, Photo Location #7

Figure 19-25. View of Proposed Radioisotope Production Facility Site from Route WW at Old Hawthorne, Photo Location #8

19.3.1.2.2 Tallest Structures

The tallest structural components of the RPF would be the three exhaust stacks, which extend 22.9 m (75 ft) high. The next highest portion of the building, the high bay, would be the second story above the process area, at 19.8 m (65 ft). The stacks would be visible from approximately 3.2 km (2 mi) away.

The scenic vistas of the nation's national parks and wilderness areas are protected under amendments of the Clean Air Act. Protected areas are known as Federal Class 1 areas. Congress declared the following as a national visibility goal for these areas:

> *The prevention of any future, and the remedying of any existing impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution.*
> (42 U.S.C. § 7491 Section 169A)

To address the problem of long-range transport of regional haze and to meet this goal, the EPA adopted regulations, known as the Regional Haze Rule (40 CFR 51, "Regional Haze Regulations"), to address visibility impairment caused by one or a small group of human-made sources generally located in close proximity to a specific Class I area. States are required to improve visibility in these areas incrementally over the next 60 years. The first milestone is to develop a regional haze plan to reduce causes of haze to make reasonable progress by 2018.

There are no Federal Class I areas, as defined by 40 CFR 81.416, "Identification of Mandatory Class I Federal Areas where Visibility is an Important Value, Missouri," within Boone County, Columbia, the ROI, or anywhere near the proposed RPF site. The site lies within the BLM Northeastern States Field Office planning district, which covers 20 states. The Milwaukee Field Office administers the nearest public land to the RPF site. Within that area, there are no BLM-managed acres that are classified as Class I. The RPF site also lies within the Forest Service Eastern Region. The Forest Service manages the only two Class I areas in the state. These Class I areas include the Hercules-Glades Wilderness Area, a 4,983.7 ha (12,315-acre) area approximately 352.4 km (219 mi) south of Columbia, and the Mingo Wilderness Area, a 3,237.5 ha (8,000-acre) area approximately 420 km (261 mi) southeast of Columbia.

19.3.1.2.3 Aesthetic and Scenic Quality Rating

The scenic quality of the proposed site was rated using the BLM Visual Resource Management System (BLM, 1986). 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, and cultural modifications. Notes are taken at the observation points describing these characteristics and scored according to the criteria shown in Table 19-17. The RPF site scoring and photographs were used to determine the visual quality of the site. Scenic quality is classified as either A, B, or C, based on total score, with A being a high-quality visual classification and C being a low-quality visual rating. Table 19-18 shows the scoring and the final NWMI site determination as a C classification.

Table 19-17. Scenic Quality Inventory and Evaluation Chart

Key factors	Rating criteria and score		
Landform	High vertical relief as expressed in prominent cliffs, spires, or massive rock outcrops; or severe surface variation or highly eroded formations, including major badlands or dune systems; or detail features dominant and exceptionally striking and intriguing, such as glaciers Score: 5	Steep canyons, mesas, buttes, cinder cones, and drumlins; or interesting erosional patterns or variety in size and shape of landforms; or detail features that are interesting though not dominant or exceptional Score: 3	Low rolling hills, foothills, or flat valley bottoms; or few or no interesting features Score: 1
Vegetation	A variety of vegetative types as expressed in interesting forms, textures, and patterns Score: 5	Some variety of vegetation, but only one or two major types Score: 3	Little or no variety or contrast in vegetation Score: 1
Water	Clear and clean appearing, still, or cascading white water, any of which are a dominant factor in the landscape Score: 5	Flowing, or still, but not dominant in the landscape Score: 3	Absent or present, but not noticeable Score: 0
Color	Rich color combinations, variety, or vivid color; or pleasing contrasts in the soil, rock, vegetation, water, or snow fields Score: 5	Some intensity or variety in colors and contrast of the soil, rock, and vegetation, but not a dominant scenic element Score: 3	Subtle color variations, contrast, or interest; generally mute tones Score: 1
Influence of adjacent scenery	Adjacent scenery greatly enhances visual quality Score: 5	Adjacent scenery moderately enhances overall visual quality Score: 3	Adjacent scenery has little or no influence on overall visual quality Score: 0
Scarcity	One of a kind; or unusually memorable, or very rare within region; consistent chance for exceptional or wildflower viewing, etc. Score: 5+	Distinctive, though somewhat similar to others within the region Score: 3	Interesting within its setting, but fairly common within the region Score: 1
Cultural modifications	Modifications add favorably to visual variety while promoting visual harmony Score: 2	Modifications add little or no visual variety to the area and introduce no discordant elements Score: 0	Modifications add variety but are very discordant and promote strong disharmony Score: -4

Table 19-18. Scenic Quality Rating, by View

Scenic quality rating units	Landform	Vegetation	Water	Color	Adjacent scenery	Scarcity	Cultural modification	Total score	Scenic quality rating	Explanation
Direct view of the RPF site looking toward the northeast direction from Discovery Parkway										
Photo Loc. #3, Figure 19-20	1									Level to rolling topography, agriculture-related structures in the background
		1								Grass area, shrubs in foreground, trees in background
			0							None
				1						Little contrast in vegetation tones, mainly monochromatic
					0					Adjacent scenery is similar
						1				Common for the area
							0			Agriculture structures, utility pad
								4	C	A = 19 or more; B = 12–18; C = 11 or less
View toward the RPF site looking northeast from the North Edge of Perry Phillips Lake										
Photo Loc. #4, Figure 19-21	1									Level to rolling topography, agriculture-related structures and utility poles in the background
		1								Grass in foreground, dirt in background, trees in distance
			0							None
				1						Contrast in soil, rock, and vegetation; not unique
					0					Adjacent scenery is similar
						1				Common for the area
							0			Agriculture structures, power lines
								4	C	A = 19 or more; B = 12-18; C = 11 or less
View toward the RPF site looking southwest from intersection of New Haven and Rolling Hills Roads										
Photo Loc.#7, Figure 19-24	1									Level topography, farm field and trees in the background
		1								Pavement and grass in foreground, agriculture fields in background
			0							None
				1						Contrast in crop color is similar to contrast in grass area
					0					Adjacent scenery is similar
						1				Common for the area
							0			Pavement, power lines, signs
								4	C	A = 19 or more; B = 12-18; C = 11 or less

RPF = radioisotope production facility.