Enclosure 1

Marked up version of the Integrated Safety Analysis Summary
(revision bars, strikethroughs and underlines utilized)

urenco

INTEGRATED SAFETY ANALYSIS SUMMARY

Revision 19

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Summary of Changes for Revision 18		
Issue / Date	**Change**	**Description of Change**
18a 12-15-10	LBDCR-10-0110 11-03-10	Additional weighing system for receipt of feed cylinders on UBC pad. CC-MS-2010-0012; 70.72 = 2010-0708
	LBDCR-10-0095 11-03-10	Revise accident sequences to include the entire CRDB inventory and take credit for IROFS. CC-EG-2010-0291; 70.72 = 2010-0575
	LBDCR-10-0049 11-18-10	Clarify the GEVS charcoal filter testing CC-EG-2010-0113; 70.72 = 2010-0747
	LBDCR-10-0112 12-06-10	Restore IROFS as Sole IROFS for accident identifier EE-SEISMIC-SBM CC-LS-2010-0030; 70.72= 2010-0640
18b 01-06-11	LBDCR-10-0117 12-15-10	Add coil doors to SBM1001 First floor CC-EG-2010-0372; 70.72 = 2010-0806
	LBDCR-10-0103 10-08-10	Remove NRC Branch Technical Positions from the Code of Record table that were never issued CC-EG-2010-0324; 70.72= 2010-0821
	LBDCR-10-0116 01-03-11	Table 3.0-1 Updated to show AWS D1.1 2006 as the CRDB welding code of record & remove SAR from the "Source Document" column for both AWS D1.1 2000 and 2006. CC-EG-2010-0376; 70.72 = 2010-0803
19 01-06-11	N/A	Submittal to NRC for non substantial changes previously approved by LES

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ANSI/ANS	8.15	1995	Nuclear Criticality Control of Special Actinide Elements	SER
ANSI/ANS	8.17	1997	Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors	SER
ANSI/ANS	8.19	1996	Administrative Practices for Nuclear Criticality Safety	SAR SER
ANSI/ANS	8.20	1991	Nuclear Criticality Safety Training	SAR SER
ANSI/ANS	8.21	1995	Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors	SER
ANSI/ANS	8.22	1997	Nuclear Criticality Safety Based on Limiting and Controlling Moderators	SAR SER
ANSI/ANS	8.23	1997	Nuclear Criticality Accident Emergency Planning and Response	SER
ANSI/ANS	8.3	1997	Criticality Accident Alarm System	ISAS SER
ANSI/ANS	8.5	1996	Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Materials	SER
ANSI/ANS	8.6	1995	Safety in Conducting Sub critical Neutron-Multiplication Measurements in Situ	SER
ANSI/ANS	8.7	1998	Guide for Nuclear Criticality Safety in the Storage of Fissile Materials	SAR SER
ANSI/ANS	8.9	1987 (Reaffirmed 1995)	Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials	SER SAR
ANSI/ARI	410	2001	Forced-Circulation Air-Cooling Air-Heating Coils	SAR ISAS
ANSI/ASME	N509	1989 (Reaffirmed 1996)	Nuclear Power Plant Air-Cleaning Units and Components	SAR ISAS
ANSI/ASME	N510	1989 (Reaffirmed 1995)	Testing of Nuclear Air Treatment Systems	SAR ISAS
ANSI/AWS	D1.1	2000	Structural Welding Code – Steel	~~SAR~~ ISAS

LBDCR-10-0116

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ANSI/AWS	D1.1	2006 (Note: Applied to ETC cascade steelwork and CRDB ~~only~~)	Structural Welding Code – Steel	~~SAR~~ ISAS
ANSI/AWS	D1.3	Version in effect at time of manufacture	Structural Welding Code – Seet Steel	SAR ISAS
ANSI/AWS	D9.1	2000	Sheet Metal Welding Code	SAR ISAS
ANSI/HPS	N13.1	1999	Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities	SAR SER
ANSI/HPS	N13.22	1995	Bioassay Program for Uranium	SAR
ANSI/HPS	N13.30	1996	Performance Criteria for Radio bioassay	SAR
ANSI/ICC	A117.1	1998 (Note: only applicable to select buildings)	Accessible and Usable Buildings and Facilities	Letter to Mr. Krich from Fermin Aragon April 25, 2006
ANSI/IEEE	279	1971	Criteria for Protection Systems for Nuclear Power Generating Stations	ISAS SER SAR
ANSI/IEEE	383	1974 (R1992)	IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices and Connections for Nuclear Power Generating Stations	ISAS SAR
ANSI/IEEE	C2	2002	National Electrical Safety Code	SAR ISAS
ANSI/ISA	S67.04	1994	Setpoints for Nuclear Safety-Related Instrumentation	SAR
AREVA / LES		2006 Rev. 3	MONK8A Validation and Verification	SAR SER
ARI	430	1980	Standard for Central Station Air-Handling Units	SAR ISAS
ASCE	4	1998	Seismic Analysis of Safety Related Nuclear Structures	ISAS

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Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NMAC	NMPC, 14.8.2	2003 (Note: Adopts and Amends UPC, 2003) (Note: 100-Year 1-Hr Rain event should not be based on NMPC. It should be based on the Rain Load section of SER section 3.3.1.2.2.2)	New Mexico Plumbing Code	Letter to Mr. Krich from Fermin Aragon April 25, 2006 NMAC NMCBC
NMAC	NMWQCC20.6.2	2002	Ground and Surface Water Protection(Note: NMAC 20.6.2.3103 requires Standards for Groundwater of 10,000mg/L TDS Concentrations or Less)	ER
NMAC	NMWQCC 20.6.4	2002	Standards for Interstate and Intrastate Surface Waters	ER
NRC	Branch Position	April 1993	Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material, Branch Technical Position	SAR SER
NRC	Branch Position	1997 Rev. 4	HICB-11, Guidance on Application and Qualifications of Isolation Devices (Chapter 7, BTP 7-11 of NUREG 0800)	SAR
NRC	Branch Position	1997 Rev. 4	HICB-17, Guidance on Self-Test and Surveillance Test Provisions (Chapter 7, BTP 7-17 of NUREG 0800)	SAR
~~NRC~~	~~Branch Position~~	~~April 1993~~	~~License Condition for Leak-Testing Sealed Byproduct Material Sources, Branch Technical Position~~	~~SAR SER~~
~~NRC~~	~~Branch Position~~	~~April 1993~~	~~License Condition for Leak-Testing Sealed Sources Which Contain Alpha and/or Beta-Gamma Emitters, Branch Technical Position~~	~~SAR~~
~~NRC~~	~~Branch Position~~	~~April 1993~~	~~License Condition for Leak-Testing Sealed Uranium Sources, Branch Technical Position~~	~~SAR~~

LBDCR-10-0103

The Hardened area is completely enclosed by a tilt-up concrete panel system and cast-in-place roof slab, designed to resist tornado forces without failure. The exterior finish system of this portion of the building consists of metal building panels over insulation board.

The Non-Hardened area is a standard pre-engineered steel frame system with horizontal steel girt members, steel roof purlins and metal panel exterior walls and roof.

3.3.1.3 Cylinder Receipt and Dispatch Building (CRDB)

The overall layout of the CRDB is presented in Figures 3.3-12 and 3.3-13. The CRDB is located between two Separations Building Modules and directly north of the Technical Services Building.

3.3.1.3.1 Design Description

The CRDB is a one story building with a two story interior Bunkered Area. The CRDB utilizes steel frame and steel panel construction. The Bunkered Area inside the CRDB is comprised of reinforced poured concrete. The CRDB is approximately 240.3 m (788 ft) long, 48.1 m (158 ft) wide, and 14.8 m (48.5 ft) high (at the eave) and totals an area of 15,123 m^2 (162,782 ft^2) (including the 2nd floor of the Bunkered Area) . It is classified as an H-4 Occupancy area by the New Mexico Commercial Building Code (NMCBC). It is classified as a Type I-B Construction by the NMCBC and as a Type II (222) Construction by NFPA 220. The CRDB is separated from the TSB by three-hour fire-rated construction.

3.3.1.3.2 Functional Areas and Major Components

~~All~~ UF_6 (48Y) feed and uranium byproduct (UBC or tails) cylinders and (30B) product cylinders are received and dispatched by the facility through the CRDB. It is designed to include space for the following: LBDCR-10-0110

Outside the CRDB's Bunkered Area:

- Loading and unloading of cylinders
- Inventory weighing
- Preparation and storage of protective cylinder overpacks
- Buffer storage of feed cylinders
- Semi-finished product storage
- Final product storage
- Prepared cylinder storage
- Staging (temporary storage) of tails and empty feed cylinders.

Inside the CRDB's Bunkered Area:

- Equipment decontamination
- Rebuilding of vacuum pumps
- UF_6 cylinder valve repair
- Solid waste collection and packaging
- Collection and treatment of liquid effluents

- Provide a means of functionally testing the performance of production centrifuges to ensure compliance with design parameters
- Investigate production and operational problems.
- Test either a single centrifuge or two simultaneously

The Centrifuge Post Mortem Facility is designed for investigating problems with production centrifuges. Based on 30 years of European experience, the demand for centrifuge post mortems is infrequent.

The principal functions of the Centrifuge Post Mortem Facility are:

- To facilitate dismantling of contaminated centrifuges using equipment and processes, which minimize the potential to contaminate personnel or adjacent facilities
- To prepare potentially contaminated components and materials for transfer prior to disposal.

Centrifuges are brought into the facility on a specially designed transport cart . The facility is also equipped with radiological monitoring devices, toilets and washing facilities, and hand, foot and clothing personnel monitors to detect surface contamination.

The Centrifuge Post Mortem Facility includes a centrifuge dismantling area and an inspection area. The centrifuge dismantling area includes a stand onto which the centrifuge to be dismantled is mounted providing access to the top and bottom of the centrifuge. A local jib crane is located over the stand to enable removal of the centrifuge from the transport cart and facilitate loading onto the stand. The inspection area includes an inspection bench, portable lighting, a microscope, an endoscope and a digital video/camera.

3.3.1.4.3 Building Construction

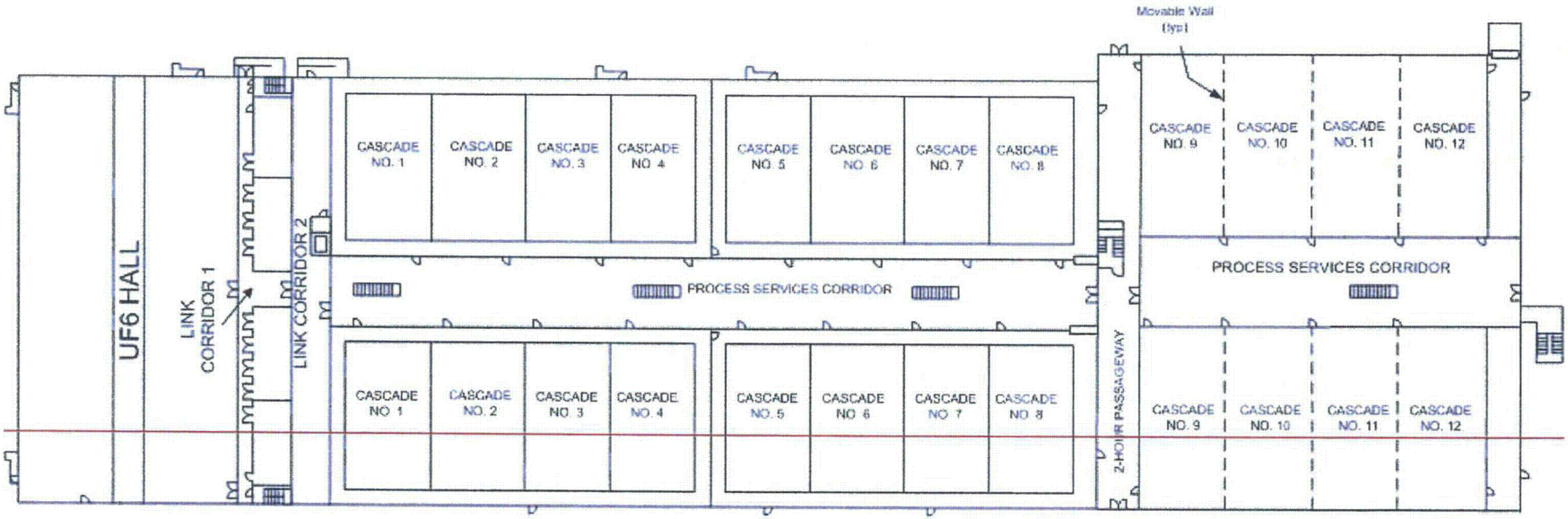
The CAB is a metal building that is constructed on a concrete slab. The floors of the CAB Assembled Centrifuge Storage Area have a floor profile quality classification of flat in accordance with ACI 117 to aid in the transport of assembled centrifuges.

Floors in the CAB (except for certain office areas) are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.5 Not Used

3.3.1.6 (See SAR § 12.2.1.4) Uranium Byproduct Cylinder (UBC) Storage Pad

The facility utilizes an area outside of the CRDB for storage of UBCs, which contain UF_6 that is depleted in ^{235}U. The tails are stored under vacuum in corrosion resistant Type 48Y cylinders. The UBC Storage Pad will also be used for buffered storage of full and empty feed (48Y) cylinders and clean, empty product (30B) cylinders. In fair weather the UBC Storage Pad can be used for material receipt. The UBC Storage Pad is shown on Figure 3.3-1, Facility Buildings and Areas. LBDCR-10-0110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CASCADE NO. 5
CASCADE NO. 6
CASCADE NO. 7
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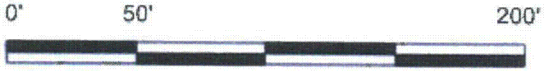
CASCADE NO. 10
CASCADE NO. 11
CASCADE NO. 12
PROCESS SERVICES CORRIDOR
2-HOUR PASSAGEWAY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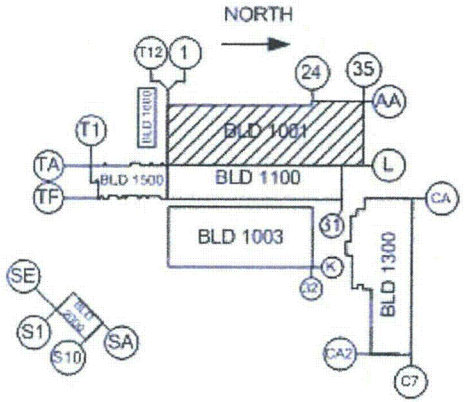
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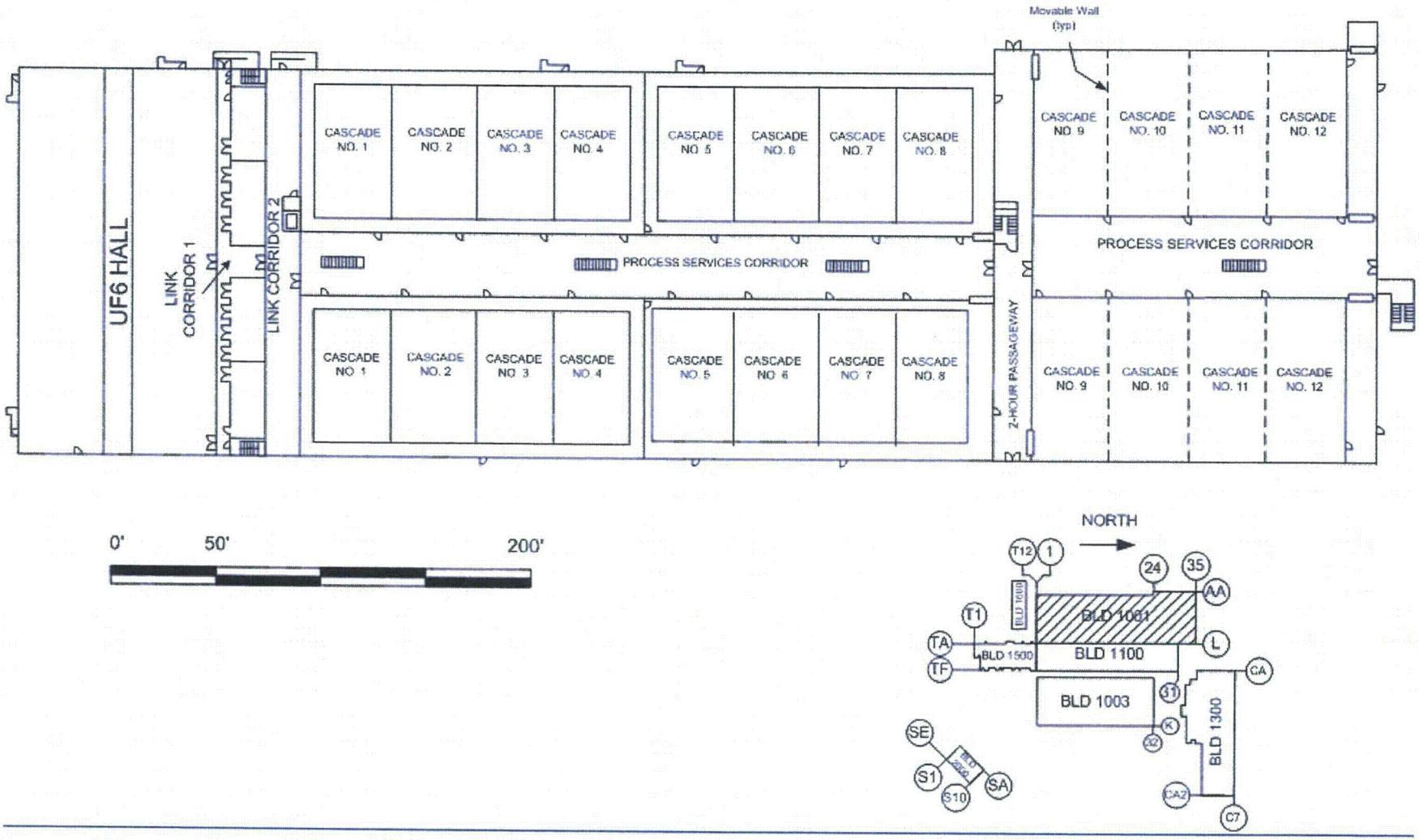

LBDCR-10-0117

Figure 3.3-2 Separations Building Module 1001 First Floor

The design and in-place testing of the Pumped Extract GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140, ASME AG-1, and ASME N510. The system includes impregnated activated carbon filters for HF removal. As such, the portions of Regulatory Guide 1.140, ASME AG-1, and ASME N510, which address activated carbon filters for radioiodine removal are not applicable. The prefilter efficiency (60-65%) is based on testing in accordance with ASME AG-1. The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1. The charcoal filter efficiency (99%) for removal of HF is based on Urenco operating experience and specifications. In-place testing and inspections of the HEPA filters will be performed in accordance with the guidance in Regulatory Guide 1.140. The frequency for performance of in-place HEPA filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140. Qualification testing, to verify HF removal efficiency, of the impregnated carbon will be performed using ASTM D6646, modified to reflect removal of HF instead of hydrogen sulfide or using an actual in situ test such as described in document ETC4044158 (Qualification of Safe by Shape GEVS Filters). Laboratory testing of samples from the impregnated carbon filters will be performed on an annual basis. Throughout the useful life of the impregnated carbon, the impregnate is progressively consumed. The laboratory testing will determine the impregnant content within the sample. The amount of impregnant present in the sample is indicative of the remaining life of carbon filter for removal of HF. Carbon filter replacement will be based on the remaining absorption capacity. The remaining filters will be replaced on differential pressure (i.e., filter loading). There is no fixed frequency for filter replacement. LBDCR-10-0049

The Pumped Extract GEVS is connected to standby diesel generators through the short break load system.

3.4.9.1.5 Instrumentation

The process variables, pressure, fan speed, and damper positioning are all controlled automatically, but can be manually operated from a local control panel. The fan speed is automatically controlled to maintain negative pressure in the system. HF monitors measure the concentration of the gas in the air stream. Also, alpha monitors are used to measure the level of radiological contamination (alpha only) present in the air stream and are located in the exhaust stack. Deviations from specified values are indicated by alarms. HF monitors are installed upstream and downstream of the filtration system and in the exhaust stack to detect the release of hazardous materials. The HF and radiological monitoring devices have non-interruptible power supplies in order to continue to function during a general power failure.

The differential pressures across each of the filters (prefilters, HEPA filters, and impregnated activated carbon filters), across the entire filter train, and across the fan aremonitored to indicate required filter changes. Additionally, a carbon temperature sensor is located at the outlet of each carbon filter to detect possible ignition of the carbon.

The Pumped Extract GEVS control system is mounted in a Local Control Panel (LCP). The LCP provides automatic control of the fans, dampers, and pressure control valves and provides local control via a Local Operator Interface (LOI) that is mounted in the LCP. Required Plant Control System (PCS) monitoring points are hardwired from the LCP to the PCS Local Control Center (LCC), or directly from the effluent monitors or airflow monitor to the LCC.

3.4.10.2.4 Design and Safety Features

Operational experience in Europe has shown that centrifuge post mortems are infrequent events. It is envisioned that no post mortem activity is required during early operational life. Consequently, it is expected that no more than 20 post mortems would be undertaken over the life of the facility.

Waste material such as carbon fiber, metal (principally aluminum), oil, paper, wipes, gloves, and contaminated disposable clothing or flushing water is generated. Operational experience in Europe has shown that uranium is found as surface contamination in the form of either UO_2F_2~~2~~ or uranium tetrafluoride (UF_4). | LBDCR-10-0095

3.4.10.3 Centrifuge Test and Post Mortem Facilities Exhaust Filtration System

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System provides exhaust of potentially hazardous airborne contaminants from the Centrifuge Test and Post Mortem Facilities. The system also ensures the PMF is maintained at a negative pressure with respect to adjacent areas during contaminated or potentially contaminated processes. The system is shown on Figure 3.4-20, Process Flow Diagram Centrifuge Test and Post Mortem Facilities Exhaust Filtration System.

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is located in the Centrifuge Assembly Building and is monitored from the Control Room.

3.4.10.3.1 Functional Description

Potentially contaminated exhaust air comes from the Centrifuge Test and Post Mortem Facilities.

The design requirements for the facility provide a large safety margin between normal and accident conditions so that no single failure could result in the release of significant hazardous material. The amounts of UF_6 in the system also preclude the release of significant quantities of hazardous material from a single failure or multiple failures. Instrumentation is provided to detect abnormal process conditions so that the process can be returned to normal by operator actions.

These requirements and operating conditions also assure "as low as reasonably achievable" personnel exposure to hazardous materials and compliance with environmental and safety criteria.

3.4.10.3.2 Major Components

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System includes the following major components.

- Duct system
- Prefilters
- Impregnated carbon filters
- HEPA filters
- One Exhaust Filtration Unit

Oil waiting to be processed is stored in the PFPE oil storage array to eliminate the possibility of accidental criticality. When ready for processing, the oil is transferred to the ~~Fomblin©~~PFPE Oil Recovery System where the uranics and hydrocarbon contaminants are separated from the oil prior to its reuse. LBDCR-10-0095

After outgassing, individual pumps are removed from the Outgas Area and placed on either of the two hydraulic stripping tables using an overhead crane. The tables can be height-adjusted, and a pump can be moved and positioned on the table. The pump and motor are stripped to component level using various hydraulic and hand tools. Using the overhead crane or mobile jig truck, the components are placed in bins ready for transportation to the Equipment Decontamination Cabinet.

3.5.14.4.2 Equipment Decontamination

Decontamination for pumps and general equipment is done in a series of steps. The equipment is put into a degreaser water bath, a citric acid bath, and is then rinsed with DI water baths. It is transported between baths in a basket using an integral monorail hoist inside the Equipment Decontamination Cabinet (Figure 3.5-21, Process Flow Diagram, Equipment Decontamination System). The decontamination process for most plant components is described below, with a typical cycle time of approximately one hour.

Degreasing takes place in the Degreaser Tank in the Equipment Decontamination Cabinet. Components requiring degreasing are cleaned manually and then immersed into the Degreaser Tank. An open top tank with a sloped bottom is used for removing the residual PFPE oil and greases that may inhibit the decontamination process. The sloped bottom construction is provided for draining the tank completely. During the degreasing process, a pump continuously recirculates the tank contents to accommodate sampling for criticality prevention. The tank has a capacity of 800 L (211 gal), and level control with a local alarm is provided to maintain the liquid level. It is furnished with an ultrasonic agitation facility, and a thermostatically controlled electric heater to maintain the temperature at 60°C (140°F). The tank has a ring header and a manual hose to rinse out residual solids/sludge with DI water after the batch has been pumped to the Liquid Effluent Collection and Treatment System. The degreased components are inspected and then transferred to the Citric Acid Tank for the decontamination part of the process.

Decontamination is accomplished by immersing the contaminated component in a citric acid bath. The Citric Acid Tank and pump system have the same components and are operated and controlled in the same fashion as the Degreaser Tank and pump system. In order to minimize uranium concentration, the rinse water from the final Rinse Water Tank is pumped into the other Rinse Water Tank (closer to the Citric Acid Tank), which in turn is pumped into the Citric Acid Tank. This counter-current system eliminates a waste product stream by concentrating the uranics in the Citric Acid Tank. The rinse water transfer pump is linked with a high level alarm on the Citric Acid Tank to prevent overfilling. After approximately 15 minutes, the component is removed from the Citric Acid Tank to be rinsed.

Uranium compounds are removed from the PFPE oil in the PFPE Oil Recovery Unit to minimize personnel exposure to airborne contamination. Dissolved uranium compounds are removed by the addition of anhydrous sodium carbonate (Na_2CO_3) to the oil container which causes the uranium compounds to precipitate into sodium uranyl carbonate ($Na_4UO_2(CO_3)_3$). The mixture is agitated and then filtered through a coarse screen to remove metal particles and small parts such as screws and nuts. This waste is transferred to the Solid Waste Collection System. The oil is then heated to 90 °C (194 °F) and stirred for 90 minutes to speed the reaction. The oil is centrifuged to remove UF_4, sodium uranyl carbonate, and various metallic fluorides. The particulate that is removed from the oil is collected and transferred to the Solid Waste Collection System for subsequent offsite disposal.

After uranium compounds are removed, trace amounts of hydrocarbons are removed in the PFPE Oil Recovery Unit by adding activated carbon to the PFPE oil and heating the mixture to 100°C (212°F) for two hours. The activated carbon adsorbs the hydrocarbons, and the carbon in turn is removed by filtration through a bed of celite. The resulting sludge is transferred to the Solid Waste Collection System for disposal.

Recovered PFPE oil is sampled, and the samples are dissolved and analyzed in the Chemical Laboratory to determine if the criteria for purity have been met. Oil that meets the criteria can be re-used in the UF_6 system while oil that does not meet the criteria is reprocessed. The following limits have been set for recovered PFPE oil purity for re-use in the plant:

- Uranium - 50 ppm by volume.
- Hydrocarbons - 3 ppm by volume.

Recovered PFPE oil is stored in 5 L (1.32 gal), plastic containers in the chemical storage area. No precautions are required to prevent criticality accidents during the handling and storage of clean PFPE oil.

3.5.15.2 Major Components

The following major components are included in this system:

A. ~~Fomblin©~~PFPE Oil Recovery Unit. One ~~Fomblin©~~PFPE Oil Recovery Unit is provided to control the release of airborne radioactive contamination or HF during oil processing. Discharge air is filtered and is discharged from the plant via the Gaseous Effluent Ventilation System. LBDCR-10-0095

B. PFPE Oil Centrifuge. One PFPE oil centrifuge is provided within the recovery unit to remove particulate from the oil. The centrifuge capacity is approximately 60 L/hr (15 gph).

3.5.15.3 Interfaces

The ~~Fomblin©~~PFPE Oil Recovery System interfaces with the following plant systems and areas: LBDCR-10-0095

A. GEVS. Exhaust from the fume hood of the ~~Fomblin©~~PFPE Oil Recovery Unit is filtered and discharged from the plant via the CRDB GEVS.

B. Solid Waste Collection System. The Solid Waste Collection System will receive uranic precipitate and filter cake resulting from the uranium and hydrocarbon removal processes, and solvent resulting from rinse-out of filters, tubing, and clean oil containers.

C. Decontamination Workshop. PFPE oil collected in the pump disassembly areas of the Decontamination Workshop is transferred to the ~~Fomblin©~~PFPE Oil Recovery System – also in the Decontamination Workshop - for processing. The PFPE oil centrifuge bowls and parts are transferred for decontamination in the Decontamination System - also in the Decontamination Workshop. LBDCR-10-0095

D. Vacuum Pump Rebuild Workshop. Cleaned PFPE oil is transferred to the Vacuum Pump Rebuild Workshop to await reuse in rebuilt pumps.

3.5.15.4 Operating Characteristics

The total annual volume of oil processed in this system is approximately 530 L (140 gal). The above system description serves to describe operating characteristics as well since oil recovery is simply a series of manual steps.

3.5.15.5 Safety Considerations

Failure of this system will not endanger the health and safety of the public. Nevertheless, design and operating features are included which contribute to the safety of plant workers. Containment of chemicals and wastes is provided by components, designated containers, and air filtration systems. Chemical reaction accidents are prevented by strict control on chemical handling procedures and physical segregation of chemicals in storage locations. PFPE oil is rated as non-combustible and is thermally stable up to 300°C (571°F). Strict control of oil temperatures during heating precludes threat of fire. To minimize worker exposure, the ~~Fomblin©~~PFPE Oil Recovery System fume hood extracts all airborne radiological contamination resulting from oil recovery. Where necessary, air suits and portable ventilation units are available for further worker protection. LBDCR-10-0095

Criticality associated with PFPE oil recovery is precluded through the control of shape, mass, and the selection of appropriate storage containers.

The maximum volume of any vessel on the ~~Fomblin©~~PFPE Oil Recovery Unit is 12 L (3.2 gal) and is intrinsically safe. However, MONK8A (SA, 2001) calculations demonstrate that the unit would remain safe even if all vessels were completely filled with uranyl fluoride-water mixture at 6.0 $^{w}/_{o}$ enrichment and at optimum moderation. Uranyl fluoride/water mixture is more conservative than a PFPE oil/UF_4 mixture. In the PFPE oil/UF_4 mixture, dissolved HF provides the moderation and HF solubility in PFPE oil is extremely low. LBDCR-10-0095

The MONK8A (SA, 2001) calculations for the ~~Fomblin©~~PFPE Oil Recovery Unit modeled the fixed vessels in their normal positions and included one 12 L (3.2 gal) container adjacent to the first mixing vessel to represent the batch of oil being moved to the unit. A 2.5 cm (0.984 in) water layer was modeled around the vessels to simulate spurious reflection. All vessels contained uranyl fluoride-water mixture as stated above, and a range of H/U atomic ratios were considered to determine the optimum moderation. The maximum value of k_{eff} for the calculations was 0.7976 at an H/U ratio of 14. LBDCR-10-0095

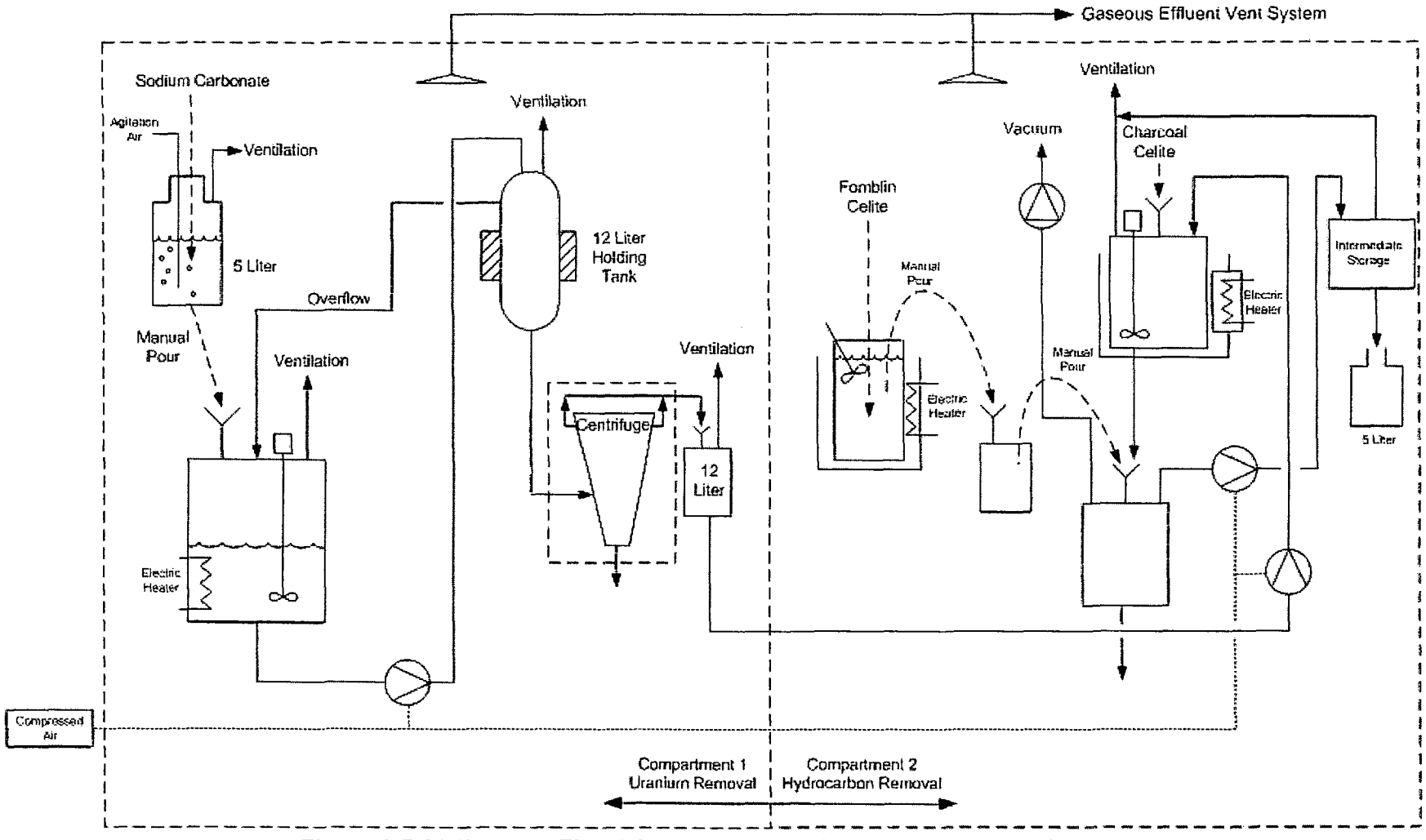

Figure 3.5-22 Process Flow Diagram ~~Fomblin~~ PFPE Oil Recovery System

LBDCR-10-0095

Table 3.7-3 External Events and Fire Accident Sequences and Risk Index

Accident Identifier	Initiating Event Index	Preventive Safety Parameter 1 or IROFS 1 Failure Index	Preventive Safety Parameter 2 or IROFS 2 Failure Index	Mitigation IROFS Failure Index	Likelihood Index T Uncontrolled (U) / Controlled (C)	Likelihood Category	Conseq. Category (Type of Accident)	Risk Index (h=f x g) Uncontrolled (U) / Controlled (C)	Comments and Recommendations	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)		
EE-SEISMIC-WORKER EVAC	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required	
EE-SEISMIC-WORKER EVAC	-2	N/A	N/A	IROFS39a -3	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk	
FF6-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required	
FF6-1	-2	IROFS35 -3	IROFS36a/ IROFS36d -3	N/A	-8 (C)	1	3 (T)	3 (C)	Acceptable Risk	LBDCR-10-0095
FF6-1	-2	IROFS35 -3	N/A	N/A	-5 (c)	1	3 (T)	3(C)	Acceptable Risk	
FF6-1	-2	N/A	IROFS36a/ IROFS36d -3	N/A	-5 (c)	1	3 (T)	3(C)	Acceptable Risk	LBDCR-10-0095
FF6-2	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required	
FF6-2	-2	IROFS36a IROFS36d -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk	LBDCR-10-0095
FF7-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required	
FF7-1	-2	IROFS36c -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk	
FF15-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required	
FF15-1	-2	IROFS35 -3	IROFS36a -3	N/A	-8 (C)	1	3 (T)	3 (C)	Acceptable Ris	
FF15-1	-2	IROFS35 -3	N/A	N/A	-5 (C)	1	3 (T)	3(C)	Acceptable Risk	

Table 3.7-3 External Events and Fire Accident Sequences and Risk Index

Accident Identifier	Initiating Event Index	Preventive Safety Parameter 1 or IROFS 1 Failure Index	Preventive Safety Parameter 2 or IROFS 2 Failure Index	Mitigation IROFS Failure Index	Likelihood Index T Uncontrolled (U) / Controlled (C)	Likelihood Category	Conseq. Category (Type of Accident)	Risk Index (h=f x g) Uncontrolled (U) / Controlled (C)	Comments and Recommendations
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	
FF15-1	-2	N/A	IROFS36a -3	N/A	-5 (C)	1	3(T)	3(C)	Acceptable Risk
FF16-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF16-1	-2	IROFS36a -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
FF16-2	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF16-2	-2	IROFS36a -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
~~FF24-1~~	~~-2~~	~~N/A~~	~~N/A~~	~~N/A~~	~~-2 (U)~~	~~3~~	~~3 (T)~~	~~9 (U)~~	~~IROFS Required~~
~~FF24-1~~	~~-2~~	~~IROFS35 -3~~	~~IROFS36a/36d -3~~	~~N/A~~	~~-8 (C)~~	~~1~~	~~3 (T)~~	~~3 (C)~~	~~Acceptable Risk~~
~~FF24-1~~	~~-2~~	~~IROFS35 -3~~	~~N/A~~	~~N/A~~	~~-5 (C)~~	~~1~~	~~3 (T)~~	~~3(C)~~	~~Acceptable Risk~~
~~FF24-1~~	~~-2~~	~~N/A~~	~~IROFS36a/36d -3~~	~~N/A~~	~~-5 (C)~~	~~1~~	~~3(T)~~	~~3(C)~~	~~Acceptable Risk~~
~~FF25-1~~	~~-2~~	~~N/A~~	~~N/A~~	~~N/A~~	~~-2 (U)~~	~~3~~	~~3 (T)~~	~~9 (U)~~	~~IROFS Required~~
~~FF25-1~~	~~-2~~	~~IROFS36d -3~~	~~N/A~~	~~N/A~~	~~-5 (C)~~	~~1~~	~~3 (T)~~	~~3 (C)~~	~~Acceptable Risk~~
~~FF25-2~~	~~-2~~	~~N/A~~	~~N/A~~	~~N/A~~	~~-2 (U)~~	~~3~~	~~3 (T)~~	~~9 (U)~~	~~IROFS Required~~
~~FF25-2~~	~~-2~~	~~IROFS36d -3~~	~~N/A~~	~~N/A~~	~~-5 (C)~~	~~1~~	~~3 (T)~~	~~3 (C)~~	~~Acceptable Risk~~
FF42-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF42-1	-2	IROFS36c -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
FF43-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF43-1	-2	IROFS36e -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
FF43-2	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required

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Table 3.7-3 External Events and Fire Accident Sequences and Risk Index

Accident Identifier	Initiating Event Index	Preventive Safety Parameter 1 or IROFS 1 Failure Index	Preventive Safety Parameter 2 or IROFS 2 Failure Index	Mitigation IROFS Failure Index	Likelihood Index T Uncontrolled (U) / Controlled (C)	Likelihood Category	Conseq. Category (Type of Accident)	Risk Index (h=f x g) Uncontrolled (U) / Controlled (C)	Comments and Recommendations
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	
FF43-2	-2	IROFS36f -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
FF44-1	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF44-1	-2	IROFS36g -3	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk
FF-WORKER EVACa	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF-WORKER EVACb	-2	IROFS36a/ IROFS36d (Failure, -3)	N/A	N/A	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk prior to worker evacuation
FF-WORKER EVACc	-2	IROFS36a/ IROFS36d (Success)	N/A	IROFS39b (Success)	-2 (c)	3	1 (T)	3 (C)	Acceptable Risk with evacuation
FF-WORKERE VACd	-2	IROFS36a/ IROFS36d (Success)	N/A	IROFS39b -2 (Failure)	-4 (C)	2	2 (T)	4 (C)	Acceptable Risk with evacuation
FF-WORKER EVACe	-2	IROFS36a/ IROFS36d (Failure, -3)	N/A	IROFS39b -2 (Failure)	-7 (C)	1	3 (T)	3 (C)	Acceptable Risk with evacuation
FF-WORKER EVAC-CABa	-2	N/A	N/A	N/A	-2 (U)	3	3 (T)	9 (U)	IROFS Required
FF-WORKER EVAC-CABb	-2	N/A	N/A	IROFS36i (Success)	-2 (C)	3	2 (T)	6 (C)	Additional IROFS Required
FF-WORKER ECAB-CABc	-2	N/A	N/A	IROFS36i -3 (Failure)	-5 (C)	1	3 (T)	3 (C)	Acceptable Risk

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Table 3.7-4 External Events and Fire Accident Descriptions

Accident Identifier: EE-SEISMIC-SBM (continued)

Add IROFS28, initiating event index (-2) as described above. As result of the addition of IROFS28 which limits the total seismic releases with the credit of the autoclave seismic qualification, the consequence analysis shows that the consequences remain high category (3) because of release from the cascades. The resulting risk index (9), therefore, additional IROFS are required. (IROFS27e and IROFS28 applied)

Evaluate failure of IROFS28. A failure probability index of (-3) was selected for IROFS28. This corresponds to a single passive engineered IROFS per NUREG-1520. Consequence category is high (3). The resulting risk index is (3) which is acceptable risk. (IROFS27e and IROFS28 applied)

Add IROFS41, initiating event index (-2) as described above. As a result of the addition of IROFS41 which limits the total seismic releases with the credit for qualified piping, consequence analysis shows that the consequences remain high category (3) because of release from the autoclaves. The resulting risk index is (9); therfore, additional IROFS are required. (IROFS27e and IROFS41 applied)

Evaluate failure of IROFS41. A failure probability index of (-3) was selected for IROFS41. This corresponds to a single passive engineered IROFS per NUREG-1520. . Consequence category is high (3). The resulting risk index is (3) which is acceptable risk. (IROFS27e and IROFS41 applied)

Add IROFS28, initiating event index (-2) as decribed above. As a result of the addition of IROFS28 which limits the total seismic releases with the credit of the autoclave seismic qualification, consequence anaylsis shows that the consequences have been mitigated to a low category (1) for both workers (including facility and site workers) and the public. The resulting risk index is (3), which is acceptable risk. (IROFS27e and IROFS41 and IROFS28 applied)

Evaluate failure of IROFS28. A failure probability index of (-3) was selected for IROFS28. This corresponds to a single passive engineered IROFS per NUREG-1520. Consequence category is high (3). The resulting risk index is (3) which is acceptable risk. (IROFS27e and IROFS41 and IROFS28 applied)

NOTE: Although there are multiple IORFS for this accident identifier, each IROFS is the sole item preventing or mitigating a chemical release specifically from the area to which the item applies. IROFS27e mitigates chemical releases due to building collapse. IROFS28 prevents the chemical release from an operating release from an operating autoclave with a 30B product cylinder in liquid state. Finally, IROFS41 mitigates the chemical release from the cascade system piping including centrifuges and cascade header pipework.

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Table 3.7-4 External Events and Fire Accident Descriptions

Accident Identifier: FF6-1 (CRDB General Areas[external fire])

(See Table 4.1-2) The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.

The uranium inventory is up to 9.434E6 kg (2.080E7 lb) of UF_6. This includes the combined inventory from the CRDB Shell Area (which is the vast majority of the inventory): 9.430E6 kg (2.098E7 lb~~) and consists~~ of UF_6 contained in 48Y and 30B cylinders located in storage or transit into and out of the area via overhead crane or on a cylinder transporter (to and from the UF_6 Handling Area) plus an additional 3,575 kg (7,880 lb) of UF_6 contained in the CRDB Bunkered Area: (assumes 500 kg (1100 lb) plus 2,277 kg (5020 lb) from a full 48Y cylinder in the Ventilated Room, 500 kg (1100 lb) of UF_6 in the Solid Waste Collection Room, 250 kg (5500 lb) of UF_6 in the Chemical Lab, and 48 kg (106 lb) of UF_6 in the Decontamination Workshop.

The uncontrolled event is fire propagating into this area from other areas that could result in a release of the UF_6 inventory (failure of IROFS35: automatic closure of fire-rated barrier opening protectives (e.g., doors dampers, penetration seals, ~~fusable~~ fusible links) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material). This event was analyzed to have a high consequence. LBDCR-10-0095

For the controlled event, fire would not propagate into the area due to (1) automatic closure of fire-rated barrier opening protectives (e.g., doors dampers, penetration seals, ~~fusable~~ fusible links) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material (IROFS35) and (2) administratively limit transient combustibles in the area of concern and adjacent areas (IROFS36a~~/36d~~); for the CRDB Bunkered Area, administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low (IROFS36a and IRFOS36d for the Ventilated Room). If cylinder is not present in the Ventilated Room the fir presumes that up to 50 kg (110 lb) of uranic material/HF could be present in open 12 L (3.2 gal) containers and the bulking drum during transfer/bulking operations and driven off in the event of a fire. For a cylinder present in the Ventilated Room, the cylinder damage caused by a fire is already bounded by cylinders located elsewhere in the CRDB. The remaining uranic material/HF inventory in the sealed metal drums, chemical traps, and waste containers was discounted as not being released during this fire due to insufficient combustibles being present to cause failure of the cylinder or metal container (IROFS36d).

The failure probability index for IROFS35 fire barriers was determined to be (-3). This corresponds to an active engineered IROFS per NUREG-1520. The IROFS justification for high availability is discussed in Section 3.8.3.

The failure probability index for administrative controls/procedures of IROFS36a~~/d~~ and IROFS36d was determined to be (-3). The NUREG -1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.

Table 3.7-4 External Events and Fire Accident Descriptions

Accident Identifier: FF6-2 (CRDB General Areas [external fire])

(See Table 4.1-2) The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.

The uranium inventory is up to 9.434E6 kg (2.080E7 lb) of UF_6. This includes the combinded inventory from the CRDB Shell Area (which is the vast majority of the inventory): 9.430E6 (2.0798E7 lb~~) and consists~~ of UF_6 contained in 48Y and 30B cylinders located in storage or transit into and out of the area via overhead crane or on a cylinder transporter (to and from the UF_6 Handling Area) plus an additional 3,375 kg (7,440 lb) of UF_6 contained in the CRDB Bunkered Area: (assumes 500 kg (1100 lb) plus 2,277 kg (5020 lb) from a full 48Y cylinder in the Ventilated Room, 500 kg (1100 lb) of UF_6 in the Solid Waste Collection Room, 250 kg (550 lb) of UF_6 in the Chemical Lab, and 48 kg (106 lb) of UF_6 in the Decontaomination Workshop).

The uncontrolled event is a fire involving excessive transient combustibles within the CRDB that could result in a release of the UF_6 inventory (failure of IROFS36a or IROFS36d: administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic materials at risk to ensure consequences to the public are low). This event was analyzed to have a high consequence. LBDCR-10-0095

For the controlled event, a fire considering expected in-situ and transient combustibles would be a low consequence event. The UF_6 inventory was discounted as not being released during a fire due to insufficient combustibles being present to cause failure of a cylinder. Preventive measures are to administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic materials at risk to ensure consequences to the public are low (IROFS36a); for the CRDB Bunkered Area, administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material compenents/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low (IROFS36a and IROFS36d for the Ventilated Room). If cylinder is not present in the Ventilated Room the fire presumes that up to 50 kg (110 lb) of uranic material/HF could be present in open 12 L (3.2 gal) containers and the bulking drum during transfer/bulking operations and driven off in the event of a fire. For a cylinder present in the Ventilated Room, the cylinder damage caused by a fire is already bounded by cylinders located elsewhere in the CRDB. The remaining uranic material/HF inventory in the sealed metal drums, chemical traps, and waste containers was discounted as not being released during this fire dur to insufficient combustibles being present to cause failure of the cylinder or metal containers (IRFOS36d).

The failure probability index for administrative controls/procedures of IROFS36a and IROFS36d was determined to be (-3). The NUREG-1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.

Table 3.7-4 External Events and Fire Accident Descriptions

Accident Identifier: FF7-1 (Cylinder Transporters/Movers)

The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.

The uranium inventory would be one or more UF_6 cylinders (48Y, or a 30Bs) in transit.

The uncontrolled event is a fire involving excessive combustibles on any onsite cylinder transporter/mover that could result in a release of the UF_6 inventory (failure of IROFS36c: administratively limit onsite UF_6 cylinder transporters/movers to ensure only use of electric drive or diesel powered with a fuel capacity of less than 280 L (74 gal). This event was analyzed to have a high consequence.

For the controlled event, a fire considering expected in-situ and transient combustibles would be a low consequence event. The UF_6 inventory was discounted as not being released during a fire due to insufficient combustibles being present to cause failure of a cylinder. Cylinder transporter/mover design will be limited to be either electric drive or diesel drive with a fuel capacity of less than 280 L (74 gallons) (IROFS36c). Diesel powered onsite UF_6 cylinder transporters/movers are only used for cylinder transport outdoors or in the CRDB truck Bay. IROFS36c does not apply to the CAB.

The failure probability index for administrative controls/procedures of IROFS36c was determined to be (3). The NUREG-1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.

Accident Identifier: FF15-1 (UF_6 Handling Area - typical for 3 modules/ Blending and Liquid Sampling Area)

The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.

The uranium inventory is up to 4.00E5 kg (8.82E5 lb) in the UF_6 Handling Area and 1.46E5 kg (3.22E5 lb) in the Blending and Liquid Sampling Area and consists of UF_6 contained in cylinders, piping, manifolds, and hoses. Additional uranic material/HF inventory could be present on the carbon/alumina traps that capture UF_6 from the various feed, product, and tails system cold traps.

The uncontrolled event is fire propagating into this area from other areas that could result in a release of the uranium inventory (failure of IROFS35: automatic closure of fire-rated barrier opening protectives (e.g., doors, dampers, penetration seals, ~~fusable~~ fusible links) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material). This event was analyzed to have a high consequence. LBDCR-10-0095

For the controlled event, fire would not propagate into the area due to automatic closure of fire-rated barrier opening protectives (e.g., doors, dampers, penetration seals) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material (IROFS35) and (2) administratively limit transient combustibles in the area of concern and adjacent areas (IROFS36a).

The failure probability index for fire barriers was determined to be (-3). This corresponds to an active engineered IROFS per NUREG-1520. The IROFS justification for high availability is discussed in Section 3.8.3.

The failure probability index for administrative controls/procedures of IROFS36a was determined to be (-3). The NUREG-1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.

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Table 3.7-4 External Events and Fire Accident Descriptions

~~Accident Identifier: FF24-1 (CRDB Ventilated Room)~~

~~(See Table 4.1-2) The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.~~

~~The uranium inventory is up to 500 kg (1100 lb) contained in 12 L (3.2 gal) metal containers and 210 L (55 gal) drums. Additional uranium inventory is present (periodically) in the form of a single 48Y or 30B cylinder present in the room for valve maintenance/change-out.~~

~~The uncontrolled event is fire propagating into this area from other areas that could result in a release of the uranium inventory (failure of IROFS35: automatic closure of fire-rated barriers opening protectives (e.g., doors, dampers, penetration seals, fusable links) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material). This event was analyzed to have a high consequence.~~

~~For the controlled event, fire would not propagate into the area due (1) to automatic closure of fire-rated barriers opening protectives (e.g., doors, dampers, penetration seals) to ensure the integrity of area fire barriers prevents fire from propagating into areas containing uranic material (IROFS35) and (2) administratively limit transient combustibles in the area of concern and adjacent areas (IROFS36a/36d).~~

~~The failure probability index for fire barriers was determined to be (-3). This corresponds to an active engineered IROFS per NUREG-1520. The IROFS justification for high availability is discussed in Section 3.8.3.~~

~~The failure probability index for administrative controls/procedures of IROFS36a was determined to be (-3). The NUREG-1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.~~

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Table 3.7-4 External Events and Fire Accident Descriptions

~~Accident Identifier: FF25-1 (CRDB Ventilated Room)~~

~~(See Table 4.1-2) The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.~~

~~CRDB Ventilated Room – The uranium inventory is up to 500 kg (1100 lb) contained in 12 L (3.2 gal) metal containers and 210 L (55 gal) drums. Additional uranium inventory is present (periodically) in the form of a single 48Yor 30B cylinder present in the room for valve maintenance/change-out.~~

~~The uncontrolled event is a fire involving excessive transient combustibles within the area that could result in a release of the uranium inventory (failure of IROFS36d: administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low). This event was analyzed to have a high consequence.~~

~~For the controlled event, a fire considering expected in-situ and transient combustibles would be a low consequence event. It is assumed that a fire in improperly placed transient combustibles could cause failure of the nitrogen hose or vent line piping used to bleed gas from cylinders during valve servicing and/or subsequent nitrogen pressure test. The resulting release would be bounded by a feed or tails cylinder (48Y has the largest inventory) which results in a puff release at the 1.4 bar (20.3 psia) valve test pressure with a subsequent pouring cylinder release at room temperature. The puff releases 3.83 kg of UF_6 and the continuing release is a cumulative 0.42 kg of UF_6 over 30 minutes. The remaining uranic material/HF inventory in the cylinder, sealed metal drums, chemical traps, and waste containers was discounted as not being released during this fire due to insufficient combustibles being present to cause failure of the cylinder or metal containers. Preventive measures are to administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low (IROFS36d).~~

~~The failure probability index for administrative controls/procedures of IROFS36d was determined to be (-3). The NUREG-1520 criteria – a routine administrative IROFS – applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.~~

Table 3.7-4 External Events and Fire Accident Descriptions

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~~Accident Identifier: FF25-2 (CRDB Ventilated Room)~~

~~(See Table 4.1-2) The frequency index number for the initiating event was determined to be (-2). The NUREG-1520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was based on evidence from similarly designed Urenco European plants which have a combined plant history of greater than 30 yrs in which no fire events have occurred in any uranium areas.~~

~~The uranium inventory is up to 500 kg (1100 lb) contained in 12 L (3.2 gal) metal containers and 210 L (55 gal) drums. Additional uranium inventory is present (periodically) in the form of a single 48Y or 30B cylinder present in the room for valve maintenance/change-out.~~

~~The uncontrolled event is a fire involving excessive transient combustibles within the area that could result in a release of the uranium inventory (failure of IROFS36d: administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low). This event was analyzed to have a high consequence.~~

~~For the controlled event, a fire considering expected in-situ and transient combustibles would be a low consequence event. The fire presumes that up to 50 kg (110 lb) of uranic material/HF could be present in open 12 L (3.2 gal) containers and the bulking drum during transfer/bulking operations and driven off in the event of a fire. The remaining uranic material/HF inventory in the cylinder, sealed metal drums, chemical traps, and waste containers was discounted as not being released during this fire due to insufficient combustibles being present to cause failure of the cylinder or metal containers. The preventive measures are to administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low (IROFS36d).~~

~~The failure probability index for administrative controls/procedures of IROFS36d was determined to be (-3). The NUREG-1520 criteria – a routine administrative IROFS applies. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.~~

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Product Piping (largest piping diameter in the system)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of pipe diameter, amount of ~~U^{236}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Product Piping Arrangement	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMT		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
WS1001 & WS251 Product Roots Pumps	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters (each pump)		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Roots Pump volume, amount of ~~U^{236}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
WS1001 & WS251 Product Roots Pump Set	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Product Cold Trap	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Cold Trap diameter, amount of ~~U^{236}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Product Cold Traps	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Carbon Type - A Trap (Product Vent Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Carbon Trap diameter, amount of ~~U^{236}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Al_2O_3 Type-A Trap (Product Vent Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Aluminum Oxide Trap diameter, amount of ~~U~~ ^{236}~~235~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Al_2O_3 Adsorption Oil Filter (Product Vent Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U~~ ^{236}~~235~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Product Vent Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U~~ ^{236}~~235~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Product Vent Pump and Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U~~ ^{236}~~235~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Product Vent Pump and Trap Set	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Assay Sampling Piping (largest pipe in system)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of pipe diameter, amount of ~~U~~ ^{236}~~235~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Assay Sampling Piping Arrangement	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMT Bounded by Product Piping Arrangement		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Mixed Bed (Al_2O_3 & C) Type-A Tra (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Al_2O_3 Adsorption Oil Filter (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	
Assay Sampling Rig	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT Bounded by Product Pump & Trap Set		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Cold Trap (K300) (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of component diameter, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Mixed Bed (Al_2O_3 & C) Type-A Trap (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Al_2O_3 Adsorption Oil Filter (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
WSU251 Roots Pump (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Mobile Maintenance Rig	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Pipette	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Pipette diameter, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Upset Conditions					
All			More Heat	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more heat condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter values for amount of ~~U^{235}~~ ^{235}U and enrichment.	LBDCR-10-0095
All			More Pressure	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more pressure condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter values for amount of ~~U^{235}~~ ^{235}U and enrichment.	LBDCR-10-0095
All			Corrosion/Erosion	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a corrosion/erosion condition that would affect the maintenance of margin to criticality associated with design and maximum operating parameter values for physical arrangement.	

Table 3.7-7 Product Take-off System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009614				
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (Design Value, See Note) (C)**	**Review of Upset Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**
All			Loss of Confinement or Leakage	Based on qualitative assessment, postulated loss of confinement or leakage will not result in any appreciable accumulation of ~~U^{236}~~ ^{235}U material because of physical limitations of the process (sub-atmospheric). As a result, loss of confinement does not result in a potential for criticality and therefore its consequence is low. LBDCR-10-0095
All			Fire	Components are protected from fire to ensure the safe design attribute of physical arrangement is not adversely impacted. The application of IROFS36a and its implementing procedure provides control of transient combustibles, limiting the fire magnitude and location in areas containing uranic material.
All			Maintenance	Approved maintenance procedures will be used to ensure that maintenance does not adversely impact the safe design attribute of physical arrangement. Maintenance is part of the generic management measures as described in Section 3.1.8.3 of the ISA Summary.
SBD Components by Physical Arrangement			Impact/Drop	Components are protected from impact/drop where necessary to ensure the safe design attribute of physical arrangement is not adversely impacted. Seismic II/I design criteria apply to support and anchorages of SBD components whose as-designed, safe configuration must be maintained during a design basis earthquake (DBE). Meeting these criteria provides protection from impact/drop due to a bounding event (i.e., DBE).
SBD Components by Physical Arrangement			External Events (Construction on Site)	Bounded by the seismic, tornado missile or impact/drop event in accordance with the ISA Meeting Minutes on Operate While Constructing.
SBD Components by Physical Arrangement			External Events (Failure of Above-Ground Liquid Storage Tanks)	Criticality due to this event is not credible, as it is bounded by local intense precipitation and protection from floods is no longer required as a result of LAR-08-07 approved by NRC SER (NRC, 2009).
SBD Components by Physical Arrangement			External Events (Hurricane)	Not a design basis event for the NEF site due to its distance from the coast (ISA Summary, Section 3.2.3.4.3)

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Tails Piping (largest piping diameter in the system)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of pipe diameter, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Tails Piping Arrangement	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMT		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
WS1001 & WS251 Tails Roots Pumps	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters (each pump)		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Roots Pump volume, amount of ~~U~~^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
WS1001 & WS251 Tails Roots Pump Set	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT Bounded by Product Pumps		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Mixed Bed (Al_2O_3 & C) Type-A Trap (Tails Evacuation Rig)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR 10-009
Al_2O_3 Adsorption Oil Filter (Tails Evacuation Rig)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Tails Evacuation Rig)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Tails Evacuation Rig)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Tails Evacuation Rig	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT Bounded by Product Pump & Trap Set		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Assay Sampling Piping (largest pipe ID in system)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of pipe diameter, amount of ~~U235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCI 10-00
Assay Sampling Piping Arrangement	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMT Bounded by Product Piping Arrangement		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Mixed Bed (Al_2O_3 & C) Type-A Trap (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Al_2O_3 Adsorption Oil Filter (Assay Sampling Rig)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Assay Sampling Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Assay Sampling Rig	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT Bounded by Product Pump & Trap Set		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Cold Trap (K300) (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of component diameter, amount of ~~U~~ ~~235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Mixed Bed (Al_2O_3 & C) Type-A Trap (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U~~ ~~235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Al_2O_3 Adsorption Oil Filter (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U~~ ~~235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U~~ ~~235~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
D40-BCS Rotary Vane Pump (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
WSU251 Roots Pump (Mobile Maintenance Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Mobile Maintenance Rig	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Pipette	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Pipette diameter, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Upset Conditions					

Table 3.7-8 Tails System

Criticality Assessment of Passive Safe-By-Design Components - ETC4009609					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
All			More Heat	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more heat condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter values for amount of ~~U^{235}~~ ^{235}U and enrichment.	LBDCR-10-0095
All			More Pressure	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more pressure condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter values for amount of ~~U^{235}~~ ^{235}U and enrichment.	LBDCR-10-0095
All			Corrosion/Erosion	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a corrosion/erosion condition that would affect the maintenance of margin to criticality associated with design and maximum operating parameter values for physical arrangement.	
All			Loss of Confinement or Leakage	Based on qualitative assessment, postulated loss of confinement or leakage will not result in any appreciable accumulation of ~~U^{235}~~ ^{235}U material because of physical limitations of the process (sub-atmospheric). As a result, loss of confinement does not result in a potential for criticality and therefore its consequence is low.	LBDCR-10-0095
All			Fire	Components are protected from fire to ensure the safe design attribute of physical arrangement is not adversely impacted. The application of IROFS36a and its implementing procedure provides control of transient combustibles, limiting the fire magnitude and location in areas containing uranic material.	
All			Maintenance	Approved maintenance procedures will be used to ensure that maintenance does not adversely impact the safe design attribute of physical arrangement. Maintenance is part of the generic management measures as described in Section 3.1.8.3 of the ISA Summary.	

Table 3.7-11 Contingency Dump System

Criticality Assessment of Passive Safe-By-Design Components – ETC4009567					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute k_{eff} < 0.95 @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Contingency Dump Piping (largest pipe in the system)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of pipe diameter, amount of ~~U^{236}~~ ^{235}U and enrichment and the conservative design analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Contingency Dump Piping Arrangement (System 440)	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See CDS Drawings & Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design analysis conditions assumed for criticality.	
Contingency Dump NaF Traps	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of NaF Trap arrangement, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Contingency Dump Buffer Volume Arrangement	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See CDS Drawings & Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	

Table 3.7-11 Contingency Dump System

Criticality Assessment of Passive Safe-By-Design Components – ETC4009567					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
Mixed Bed (Al_2O_3 & C) Type-A Trap (Contingency Dump Vacuum Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
Al_2O_3 Adsorption Oil Filter (Contingency Dump Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Al_2O_3 Oil Filter volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
ARS40-65 Exhaust Oil Filter (Contingency Dump Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Contingency Dump Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality.	LBDCR-10-0095

Table 3.7-11 Contingency Dump System

Criticality Assessment of Passive Safe-By-Design Components – ETC4009567					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
WSU251 Roots Pump (Contingency Dump Pump & Trap Set)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Contingency Dump Pump & Trap Set	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT Bounded by Product Pump & Trap Set		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.	
Cold Trap (K300) (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Mixed Bed Trap diameter, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality	LBDCR-10-0095
Mixed Bed (Al_2O_3 & C) Type-A Trap (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	DIAMETER 22.4 cm		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of AL_2O_3 Oil Filter volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality	LBDCF 10-009
AL_2O_3 Adsorption oil Filter (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Exhaust Oil Filter volume, amount of ~~U^{235}~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality	LBDCR-10-0095

Table 3.7-11 Contingency Dump System

Criticality Assessment of Passive Safe-By-Design Components – ETC4009567					
Component Description (A)	**Sequence ID (B)**	**Safe Design Attribute $k_{eff} < 0.95$ @ 6 wt % (unless physical arrangement) (Design Value, See Note) (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**	
ARS40-65 Exhaust Oil Filter (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of component diameter, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality	LBDCR-10-0095
D40-BCS Rotary Vane Pump (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of Rotary Vane Pump volume, amount of ~~U~~ ^{235}U and enrichment and the conservative design/analysis values for these parameters assumed for criticality	LBDCR-10-0095
WSU251 Roots Pump (Mobile Maint'nce Rig)	LOSS OF SAFE BY DESIGN ATTRIBUTE	VOLUME 19.3 liters		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality	
Mobile Maint'nce Rig	LOSS OF SAFE BY DESIGN ATTRIBUTE	PHYSICAL ARRNGMNT See Crit. Calc		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality	
Upset Conditions					
All			More Heat	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more heat condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter values for amount of ^{235}U and enrichment.	

Table 3.7-17 ~~Fomblin~~©PFPE Oil Recovery System

LBDCR-10-0095

Criticality Assessment of Passive Safe-By-Design Components				
Component Description (A)	**Sequence ID (B)**	**Critical Design Attribute (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**
PFPE Oil Recovery Rig	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	**PHYSICAL ARRANGEMENT**		Based on qualitative assessment, there is margin between the normal operating conditions and the conservative design/analysis conditions assumed for criticality.
			More Heat	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more heat condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter.
			More Pressure	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more pressure condition that would adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter.
			Corrosion/ Erosion	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a corrosion/erosion condition that would affect the maintenance of margin to criticality associated with design and maximum operating parameter values for physical arrangement.
			Loss of Confinement or Leakage	PFPE Oil Recovery Rig shall be protected from loss of confinement or leakage with a confinement area, the PFPE Oil Recovery Rig Cabinet, to ensure the critical design.
			Fire	Components shall be protected from fire to ensure the critical design attribute of physical arrangement is not adversely impacted.
			Maintenance	Configuration Management shall ensure that maintenance does not adversely impact the critical design attribute of physical arrangement.
			Impact/Drop	Components shall be protected from impact/drop to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Construction on Site)	Components shall be protected from construction on-Site to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Failure of Above-Ground Liquid Storage Tanks)	Components shall be protected from external flooding (Failure of Above-Ground Liquid Storage Tanks) to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Hurricane)	Components shall be protected from hurricane events to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Seismic)	Components shall be protected from seismic events to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Tornado)	Components shall be protected from tornado events to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Local Intense Precipitation)	Components shall be protected from local intense precipitation events to ensure the critical design attribute of physical arrangement is not adversely impacted.

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Table 3.7-17 ~~Fomblin~~©PFPE Oil Recovery System

Criticality Assessment of Passive Safe-By-Design Components				
Component Description (A)	**Sequence ID (B)**	**Critical Design Attribute (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**
			External Events (External Fire)	Components shall be protected from external fire events to ensure the critical design attribute of physical arrangement is not adversely impacted.
			External Events (Snow/Ice)	Components shall be protected from external ice/snow events to ensure the critical design attribute of physical arrangement is not adversely impacted.
				Double Contingency Principle is satisfied as follows. The geometry is criticality safe and no single credible event or failure has been identified whereby the geometry could become unsafe. The enrichment is also controlled such that no single credible failure could result in loss of enrichment control.
PFPE Oil Recovery Rig Cabinet	LOSS OF SAFE-BY-DESIGN ATTRIBUTE	**SLAB** 11.5 cm Keff = 1.0 @ 6 wt %		Based on qualitative assessment, there is margin between the parameter values at normal operating conditions of PFPE Oil Recovery Rig Cabinet shape and the conservative design/analysis value for this parameter assumed for criticality.
			More Heat	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more heat condition that would cause an approach to the critical safe shape and to adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter .
			More Pressure	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a more pressure condition that would cause an approach to the critical safe shape and to adversely affect the maintenance of margin to criticality associated with design and maximum operating parameter.
			Corrosion/ Erosion	Based on qualitative assessment, it is highly unlikely for a process deviation to result in a corrosion/erosion condition that would cause an approach to the critical safe shape. Materials are corrosion/erosion resistant.
			Loss of Confinement or Leakage	Based on qualitative assessment, postulated loss of the PFPE Oil Recovery Rig Cabinet or leakage will not result in any appreciable accumulation of ^{235}U material because of the robust construction of the PFPE Oil Recovery Rig Cabinet.
			Fire	Components shall be protected from fire to ensure the critical design attribute of shape is not adversely impacted.
			Maintenance	Configuration Management shall ensure that maintenance does not adversely impact the critical design attribute of shape.
			Impact/Drop	Components shall be protected from impact/drop to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Construction on Site)	Components shall be protected from construction on-Site to ensure the criticality design attribute of shape is not adversely impacted.

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Table 3.7-17 ~~Fomblin~~©PFPE Oil Recovery System

Criticality Assessment of Passive Safe-By-Design Components				
Component Description (A)	**Sequence ID (B)**	**Critical Design Attribute (C)**	**Review of Up-Set Conditions to Change Geometry (Applicable HAZOP Guidewords) (D)**	**Notes/Comments (E)**
			External Events (Failure of Above-Ground Liquid Storage Tanks)	Components shall be protected from external flooding (Failure of Above-Ground Liquid Storage Tanks) to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Hurricane)	Components shall be protected from hurricane events to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Seismic)	Components shall be protected from seismic events to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Tornado)	Components shall be protected from tornado events to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Local Intense Precipitation)	Components shall be protected from local intense precipitation events to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (External Fire)	Components shall be protected from external fire events to ensure the criticality design attribute of shape is not adversely impacted.
			External Events (Snow/Ice)	Components shall be protected from external ice/snow events to ensure the criticality design attribute of shape is not adversely impacted.
				Double Contingency Principle is satisfied as follows. The geometry is criticality safe and no single credible event or failure has been identified whereby the geometry could become unsafe. The enrichment is also controlled such that no single credible failure could result in loss of enrichment control.

Column Descriptions:

Column A: This column provides a brief description of each component.

Column B: This column identifies the accident sequence associated with the passive component.

Column C: This column identifies the critical design attribute under consideration along with the conservative values used in the criticality analysis.

Column D: This column identifies the applicable guidewords from the ISA HAZOP procedure that are used to assess the criticality design margin. Additional guidewords are addressed as applicable in the detailed assessment.

Column E: This column provides any notes, comments and concluding statements.

Table 3.8-1 Items Relied On For Safety (IROFS)

IROFS	Accident Sequence	Type of Accident	Type (1)	Class (2)	Description of Safety Function	FPIN (3)	FPIN Basis (4)	
IROFS27e	EE-SEISMIC-SBM *EE-SNOW-SBM-CRDB SHELL (T) *EE-LP-SBM-CRDB SHELL (T) *EE-TORNADO& HIGH WIND – SBM – CRDB SHELL (T) *EE-SEISMIC – CRDB SHELL (T) * (See Table 4.1-3)	Chemical	PEC	A	Design feature of SBMs and the CRDB superstructure (not including the Bunkered Area) for seismic, tornado, high wind, roof snow load, roof ponding and site flooding due to local intense precipitation, to ensure a chemical release does not exceed the 10 CFR 70.61 performance requirements. This is implemented by designing the building structures to withstand the effects of seismic, tornado, high wind, roof snow load, and local intense precipitation, consistent with the assumptions in the bases for the consequence calculations.	-3	N/A	LBDCR-10-0112
~~IROFS27e~~	~~EE-SEISMIC-SBM~~	~~Chemical~~	~~PEC~~	~~B~~	~~Design feature of SBMs and the CRDB superstructure (not including the Bunkered Area) for seismic, tornado, high wind, roof snow load, roof ponding and site flooding due to local intense precipitation, to ensure a chemical release does not exceed the 10 CFR 70.61 performance requirements.~~ ~~This is implemented by designing the building structures to withstand the effects of seismic, tornado, high wind, roof snow load, and local intense precipitation, consistent with the assumptions in the bases for the consequence calculations.~~	~~-3~~	~~N/A~~	LBDCR-10-0112
IROFS28	*EE-SEISMIC-SBM *EE-TORNADO-MISSILE-SBM-PUBLIC * (See Table 4.1-3)	Chemical	PEC	A	Design feature to maintain Product Liquid Sampling Autoclave leak tight integrity. This is implemented by providing a seismic design and tornado missile design of the Product Liquid Sampling Autoclave such that post-event total autoclave leakage is limited to that assumed in the consequence analyses.	-3	N/A	LBDCR-10-0112
~~IROFS28~~	~~*EE-SEISMIC-SBM~~ ~~*(See Table 4.1-3)~~	~~Chemical~~	~~PEC~~	~~B~~	~~Design feature to maintain Product Liquid Sampling Autoclave Leak tight integrity~~ ~~This is implemented by providing a seismic design and tornado missile design of the Product Liquid Sampling Autoclave such that post-event total autoclave leakage is limited to that assumed in the consequence analyses.~~	~~-3~~	~~N/A~~	LBDCR-10-0112

Table 3.8-1 Items Relied On For Safety (IROFS)

IROFS	Accident Sequence	Type of Accident	Type (1)	Class (2)	Description of Safety Function	FPIN (3)	FPIN Basis (4)	
IROFS35	*FF6-1 FF15-1 ~~*FF24-1~~ *(See Table 4.1-3)	Chemical	AEC	B	Automatic closure of fire-rated barrier opening protectives (e.g., doors, dampers, penetration seals) to ensure the integrity of area fire barriers prevents fires from propagating into areas containing uranic material. Barriers and protectives will be closed or self-closing (e.g., utilizing fusible links).	-3	3.8.3.35	LBDCR-10-0095
IROFS36a	~~*FF6-1~~ *FF6-2 FF16-1 FF16-2 FF-WORKER EVAC *(See Table 4.1-3)	Chemical	AC	A	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low. Transients will be controlled to limit aggregate combustible load (transient and in-situ) in the area of concern and adjacent areas.	-3	3.8.3.36a	LBDCR-10-0095
IROFS36a	*FF6-1 ~~FF15-1~~ ~~*FF24-1~~ *(See Table 4.1-3)	Chemical	AC	B	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low. Transients will be controlled to limit aggregate combustible load (transient and in-situ) in the area of concern and adjacent areas.	-3	3.8.3.36a	LBDCR-10-0095
IROFS36c	FF7-1 FF42-1	Chemical	AC	A	Administratively limit onsite UF_6 cylinder transporters/movers to ensure only use of electric drive or diesel powered with a fuel capacity of less than 280 L (74 gal).	-3	3.8.3.36c	

Table 3.8-1 Items Relied On For Safety (IROFS)

IROFS	Accident Sequence	Type of Accident	Type (1)	Class (2)	Description of Safety Function	FPIN (3)	FPIN Basis (4)	
IROFS36d	~~*FF25-1~~ ~~*FF25-2~~ *FF6-2 FF-WORKER EVAC * (See Table 4.1-3)	Chemical	AC	A	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low. Transients will be controlled to limit aggregate combustible load (transient and in-situ) in the area of concern and adjacent areas. Liquid and solid waste transfer and packing containers (except as noted below) are limited to metal only. Transfer and packing container restriction does not apply to packaging within these containers (e.g., plastic liners), to bags for transporting contaminated protective clothing and similar non- or low-contamination solids, or to laboratory size sample containers (required for maintaining sample purity).	-3	3.8.3.36d	LBDCR-10-0095
IROFS36d	*FF6-1 ~~*FF24-1~~ *(See Table 4.1-3)	Chemical	AC	B	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity or uranic material at risk to ensure consequences to the public are low. Transients will be controlled to limit aggregate combustible load (transient and in-situ) in the area of concern and adjacent areas. Liquid and solid waste transfer and packing containers (except as noted below) are limited to metal only. Transfer and packing container restriction does not apply to packaging within these containers (e.g., plastic liners), to bags for transporting contaminated protective clothing and similar non- or low-contamination solids, or to laboratory size sample containers (required for maintaining sample purity).	-3	3.8.3.36d	LBDCR-10-0095
IROFS36e	FF43-1	Chemical	AC	A	Administratively limit transient combustible loading on the UBC Storage Pad to ensure cylinder integrity. This is implemented by limiting vehicles allowed onto the pad to cylinder movers and essential vehicles with a fuel capacity limit of less than 280 L (74 gal) and maintaining storage pad drain-off to ensure no excessive fuel pooling.	-3	3.8.3.36e	

Table 3.8-1 Items Relied On For Safety (IROFS)

IROFS	Accident Sequence	Type of Accident	Type (1)	Class (2)	Description of Safety Function	FPIN (3)	FPIN Basis (4)	
IROFS39d	EE-CHEM RELEASE-WORKER EVAC-CAB EE-TORNADOMISSILE-SBM-CRDB SHELL & BUNKER WORKER	Chemical	AC	A	Administratively limit exposure by requiring worker action to evacuate the area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low. This is implemented by worker evacuation from area(s) of concern in the event of severe weather consistent with assumptions of the consequence analyses.	-3	3.8.3.39d.	
IROFS41	EE-SEISMIC-SBM	Chemical	PEC	~~B~~A	Design features to ensure cascade system pipe leak integrity. This is implemented by design considerations applied to the Cascade Halls Area that require piping integrity during a seismic event and limiting piping leakage to outside areas to ensure offsite exposure during a seismic event maintains consequences to the public low.	-3	N/A	LBDCR-10-0112
IROFS42	*PB4-4 * (See Table 4.1-3)	Chemical	AC	B	Administratively limit the cylinder fill mass to ensure cylinder integrity. This is implemented by determining the weight of product cylinders before placement and heating in the Product Liquid Sampling Autoclave. Weight limit conservative with respect to assuring cylinder integrity. If the acceptance criterion is not met, then the associated product cylinder shall not be heated.	-2	N/A	LBDCI 10-011
IROFS43	*CL3-3 * (See Table 4.1-3)	Chemical	AEC	B	Automatic trip of UF_6 sub-sampling unit hotbox heater on high hotbox internal temperature to ensure sample bottle integrity. This is implemented with a temperature switch for automatic, hardwired, fail-safe, high temperature trip of hotbox heater at UF_6 sub-sampling unit. Setpoint conservative with respect to assuring sample bottle integrity.	-2	N/A	

Table 3.8-2 Sole Items Relied On For Safety (IROFS)

IROFS Identifier	Accident Sequence	Type of Accident	Type of IROFS	Title	
IROFS27c	EE-TORNADO, TORNADO MISSILE & HIGH WIND-CRDB BUNKER (T) EE-SNOW – CRDB BUNKER (T) EE-LP-CRDB BUNKER (T)	Chemical	PEC	Design feature of buildings containing UF_6 process systems for seismic, tornado, tornado missile, high wind, roof snow load, and for roof ponding and site flooding due to local intense precipitation, to ensure UF_6 process systems integrity.	
IROFS27e	EE-SEISMIC-SBM EE-SNOW-SBM-CRDB SHELL (T) EE-LP-SBM-CRDB SHELL (T) EE-TORNADO & HIGH WIND – SBM-CRDB SHELL (T) EE-SEISMIC-CRDB SHELL (T)	Chemical	PEC	Design feature of SBMs and the CRDB superstructure (not including the Bunkered Area) for seismic, tornado, high wind, roof snow load, roof ponding and site flooding due to local intense precipitation, to ensure a chemical release does not exceed the 10 CFR 70.61 performance requirements.	LBDCR-10-0112
IROFS28	EE-SEISMIC-SBM EE-TORNADO MISSILE-SBM-PUBLIC	Chemical	PEC	Design feature to maintain Product Liquid Sampling Autoclave leak tight integrity.	LBDCR-10-0112
IROFS36a	FF6-2 FF16-1 FF16-2 FF-WORKER EVAC	Chemical	AC	Administratively limit transient combustible loading in areas containing uranic material to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.	LBDCR-10-0095
IROFS36c	FF7-1 FF42-1	Chemical	AC	Administratively limit onsite UF_6 cylinder transporters/movers to ensure only use of electric drive or diesel powered with a fuel capacity of less than 280 L (74 gal).	

Table 3.8-2 Sole Items Relied On For Safety (IROFS)

IROFS Identifier	Accident Sequence	Type of Accident	Type of IROFS	Title
IROFS36d	FF6-2 FF-WORKER EVAC~~FF25-1~~ ~~FF25-2~~	Chemical	AC	Administratively limit transient combustible loading in areas containing uranic material to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.
IROFS36e	FF43-1	Chemical	AC	Administratively limit transient combustible loading on the UBC Storage Pad to ensure cylinder integrity.
IROFS36f	FF43-2	Chemical	AC	Administratively limit designated routes for bulk fueling vehicles onsite to ensure UBC cylinder integrity.
IROFS36g	FF44-1	Chemical	AC	Administratively limit onsite vegetation fire sources to ensure integrity of important targets.
IROFS38	TT2-2 UF2-2 PT2-4 PB2-4	Chemical	AC	Administratively limit the cylinder fill mass to ensure cylinder integrity.
IROFS39a	EE-SEISMIC-WORKER EVAC EE-SEISMIC – WORKER EVAC-CAB	Chemical	AC	Administratively limit exposure by requiring worker action to evacuate area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low.
IROFS39b	FF-WORKER-EVAC-CAB	Chemical	AC	Administratively limit exposure by requiring worker action to evacuate area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low.
IROFS39c	CHEM RELEASE-WORKER EVAC CHEM RELEASE - WORKER EVAC -CAB	Chemical	AC	Administratively limit exposure by requiring worker action to evacuate area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low.
IROFS39d	EE-CHEM RELEASE-WORKER EVAC-CAB EE-TORNADO MISSILE – SBM – CRDB SHELL & BUNKER WORKER (T)	Chemical	AC	Administratively limit exposure by requiring worker action to evacuate area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low.

LBDCR-10-0095

Table 3.8-2 Sole Items Relied On For Safety (IROFS)

IROFS Identifier	Accident Sequence	Type of Accident	Type of IROFS	Title
IROFS41	EE-SEISMIC-SBM	Chemical	PEC	Design features to ensure Cascade system pipe leak integrity
IROFS45	PB1-3 RD1-1	Criticality	AC	To ensure subcriticality geometry, prior to moving a cylinder containing enriched uranium in the CRDB or the Blending and Liquid Sampling Area, verify that the stored cylinders containing enriched uranium in these areas are in a horizontal, co-planar (i.e., non-stacked), condition and that no other cylinder containing enriched uranium is in movement in the associated area.
IROFSC22	EC3-1	Criticality	AC	Administratively perform the cascade process mass balance on a periodic basis to ensure subcriticality.
IROFSC21	TT3-1 EC4-1 UF2-3 PT5-1 MR3-1 MR3-2	Chemical	PEC	Flow restriction to ensure in the event of a release that worker consequences of inhalation of uranic material and HF are low.

LBDCR-10-0112

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification		
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
FF6-1	Fire in the general CRDB Area • (IROFS35) Automatic closure of fire-rated barrier opening protectives (e.g., doors, dampers, penetration seals) to ensure the integrity of area fire barriers prevents fires from propagating into areas containing uranic material. ~~Barriers and protectives will be closed or self-closing (e.g. utilizing fusible links).~~ ▪ (IROFS36a) Administratively limit transient combustible loading in area of concern and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low. ▪ (IROFS36d) Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.	The CRDB is not available, so there is no MAR in the building. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.	The CRDB is not available, so there is no MAR in the building. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.	Applicable

LBDCR-10-0095

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification		
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
FF6-2	Fire involving excessive transient combustibles within the area resulting in a release of UF_6. • (IROFS36a) Administratively limit transient combustible loading in area containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low. • (IROFS36d) Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.	The CRDB is not available, so there is no MAR in the building. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.	The CRDB is not available, so there is no MAR in the building. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.	Applicable

LBDCR-10-0095

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification			
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2	
~~FF24-1~~	~~Fire propogating into the area resulting in a release of UF_6.~~ ~~• (IROFS35) Automatic closure of fire-rated barrier opening protectives (e.g., doors, dampers, penetration seals) to ensure the integrity of area fire barriers prevents fires from propagating into areas containing uranic material.~~ ~~Barriers and protectives will be closed or self-closing (e.g. utilizing fusible links).~~ ~~• (IROFS36a) Administratively limit transient combustible loading in area of concern and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.~~	~~The ventilated room is not completed. A Ventilated Storage Room is constructed in the UF_6 Handling Area for storage of contaminated material until the Ventilated Room is complete. Operations conducted in the ventilated room (other than storage) is not conducted in the Ventilated Storage Room. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.~~	~~Applicable~~	~~Applicable~~	LBDCR-10-0095

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification		
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
~~FF25-1~~	~~Fire involving excessive transient combustibles within the area that could result in a release of the uranium inventory~~ ~~• (IROFS36d) Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk~~	~~The ventilated room is not completed. A Ventilated Storage Room is constructed in the UF_6 Handling Area for storage of contaminated material until the Ventilated Room is complete. Operations conducted in the ventilated room (other than storage) is not conducted in the Ventilated Storage Room. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.~~	~~The ventilated room is not completed. A Ventilated Storage Room is constructed in the UF_6 Handling Area for storage of contaminated material until the Ventilated Room is complete. Operations conducted in the ventilated room (other than storage) is not conducted in the Ventilated Storage Room. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.~~	~~Applicable~~

LBDCR-10-0095

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification		
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
~~FF25-2~~	~~Fire involving excessive transient combustibles within the area resulting in a release of UF_6.~~ ~~• (IROFS36d) Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk~~	~~The ventilated room is not completed. A Ventilated Storage Room is constructed in the UF_6 Handling Area for storage of contaminated material until the Ventilated Room is complete. Operations conducted in the ventilated room (other than storage) is not conducted in the Ventilated Storage Room. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.~~	~~The ventilated room is not completed. A Ventilated Storage Room is constructed in the UF_6 Handling Area for storage of contaminated material until the Ventilated Room is complete. Operations conducted in the ventilated room (other than storage) is not conducted in the Ventilated Storage Room. Therefore, this accident sequence has no consequences exceeding 10 CFR 70.61.~~	~~Applicable~~

LBDCF 10-009

Table 4.1-2 (Table 3.7-4) Affected External Events and Fire Accident Descriptions

Accident Sequence	Description and Applicable IROFS	Justification			
		Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2	
OC1-1	Fire in a construction site preparations vehicle located near the UBC Storage Pad resulting from an impact or failure of an item construction vehicle (e.g., ruptured fuel line, electrical short). ▪ (IROFS50a) Administratively control proximity of site preparations vehicles around the UBC Storage Pad to prevent a fire from an impact with UBCs resulting in a release of UF_6. (IROFS50h) Administratively control proximity of site preparations vehicles around the UBC Storage Pad to prevent a fire from an impact with UBC resulting in a release of UF_6.	The UBC Storage Pad Construction is not complete and no cylinders are stored there for the duration of IPO	Applicable	Applicable	LBDCR-10-0095

Table 4.1-3 (Table 3.8-1) Affected IROFS

IROFS	Affected Accident Sequence	Description	Justification		
			Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
IROFS31b	VR2-7	Administratively limit ^{235}U mass in non-safe-by-design solid waste containers to ensure subcriticality by performing independent sampling and assay analysis (independent of IROFS31a). (IROFS31b is applicable to transitional accident sequence TVR1-1, See Tables 4-4 and 4-5 below.)	This operation is not conducted as the ventilated room is not available.	This operation is not conducted as the ventilated room is not available.	Applicable
IROFS31c	VR2-7	Administratively limit ^{235}U mass in non-safe-by-design solid waste containers to ensure subcriticality using bookkeeping procedures. (IROFS31c is applicable to transitional accident sequence TVR1-1, See Tables 4-4 and 4-5 below.)	This operation is not conducted as the ventilated room is not available.	This operation is not conducted as the ventilated room is not available.	Applicable
IROFS35	FF6-1 ~~FF24-1~~	Fire barriers and automatic closure of fire-rated barriers opening protectives	CRDB not available Ventilated Room not available.	CRDB not available Ventilated Room not available.	Applicable
IROFS36a	FF6-1 FF6-2	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.	CRDB not available Ventilated Room not available.	CRDB not available	Applicable

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Table 4.1-3 (Table 3.8-1) Affected IROFS

IROFS	Affected Accident Sequence	Description	Justification		
			Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2
IROFS36d	FF6-1 FF6-2~~FF24-1~~ ~~FF25-1~~ ~~FF25-2~~	Administratively limit transient combustible loading in areas containing uranic material and adjacent areas to ensure integrity of uranic material components/containers and limit the quantity of uranic material at risk to ensure consequences to the public are low.	CRDB not available Ventilated Room not available.	Ventilated Room not available.	Applicable
IROFS38	PB2-4	Administratively limit the cylinder fill mass by verifying cylinder weight is within specified trending limits once per shift during filling of the cylinder	Product Liquid Sampling System is not available.	Product Liquid Sampling System is not available in Production Phase 1a.	Applicable
IROFS39d	EE-TORNADO MISSILE – SBM – CRDB SHELL & BUNKER WORKER (T)	Administratively limit exposure by requiring worker action to evacuate area(s) of concern to ensure worker consequences of inhalation of uranic material and HF are low.	This IROFS is applicable to the SBM for all phases. CRDB not available	This IROFS is applicable to the SBM for all phases. CRDB not available	Applicable
IROFS42	PB4-4	Administratively limit the cylinder fill mass prior to placement and heating	Product Liquid Sampling System is not available.	Product Liquid Sampling System is not available in Production Phase 1a.	Applicable
IROFS43	CL3.3	Automatic trip of UF_6 sub.sampling unit hotbox heater or high hotbox internal temperature	Chemistry Lab (Sub-Sampling System) is not available.	Applicable	Applicable

LBDCR-10-0095

Table 4.1-3 (Table 3.8-1) Affected IROFS

IROFS	Affected Accident Sequence	Description	Justification			
			Initial Plant Operations (IPO)	Production Phase 1a and 1b	Production Phase 2	
IROFS50a	OC1-1	Administratively control proximity of site preparations vehicles around the UBC Storage Pad to prevent a fire from an impact with UBCs resulting in a release of UF_6.	UBC Storage Pad is not available	Applicable	Applicable	LBDCR-10-0095
IROFS50h	OC1-1	Administratively control proximity of site preparations vehicles around the UBC Storage Pad to prevent a fire from an impact with UBCs resulting in a release of UF_6.	UBC Storage Pad is not available	Applicable	Applicable	LBDCR-10-0095

Table 4.1-5 Transitional Accident Sequence Descriptions

LBDCR-10-0095

~~Accident Identifier: TVR1-2~~

~~The accident sequence is the combination of numerous conditions assumed to lead to a criticality in a container being transported. This description of this sequence is the following:~~

~~(1) The fissile material in the container and interacting components would be auranyl fluoride/water mixture at an H/U atomic ration near optimum moderation,~~

~~(2) The container, as well as other interacting components, would be nearly or completely filled with the above material at a high enough enrichment to achieve a configuration favorable for criticality (Urenco European experience is that less than 10% of container enrichment is at product enrichment levels), and~~

~~(3) The container would have to interact (i.e., proximity limit not maintained) with greater than one component containing fissile material, as interaction of the container and one other component is subcritical.~~

~~The movement of containers with uranic material is part of normal operations; the abnormal operating conition pertaining to the container concerns the assumption that the container and interacting component are filled with product UF_6 breakdown material at optimum moderation conditions. This would be extremely unlikely for a single container and even more unlikely for more than one component.~~

~~For the uncontrolled accident sequence, conditions (1) through (3) above must be met to result in a potential criticality event. Fore this accident sequence,a criticality event was assumed. A criticality even is assumed to result in a high consequence to the worker and public.~~

~~For the controlled accident sequence, the preventive measure is to administratively restrict proximity of vessels in non-designed locations containing enriched uranic material to ensure subcritical configuration by verifying the use of a safe-by-design transfer frame prior to movement of the associated container containing enriched uranic material (IROFS14a). If the acceptance criteria is not met, then the associated container containing enriched uranic material shall not be moved.~~

~~The frequency index number for the initiating event was determined to be (-2). The NUREG-1-520 criteria – no failures of this type in this facility in 30 yrs – applies. This failure frequency index was selected based on evidence from history of similarly designed Urenco-European plants, which have a combined plant history of greater than 30 yrs, and have not had a failure of this type.~~

~~A failure probability index of (-3) was selected for IROFS14a. This corresponds to an enhanced administrative IROFS per NUREG-1520. IROFS14a is enhanced by requiring independent verification of the IROFS safety function. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.~~

Table 4.1-5 Transitional Accident Sequence Descriptions

LBDCR-10-0095

~~Accident Identifier: TVR1-3~~

~~The accident sequence is the combination of numerous conditions assumed to lead to a criticality in a container being stored. This description of this sequence is the following:~~

~~(1) The fissile material in the container and interacting components, would be a uranyl fluoride/water mixture at an HIU atomic ratio near optimum moderation,~~

~~(2) The container, as well as other interacting components, would be nearly or completely filled with the above material at a high enough enrichment to achieve a configuration favorable for criticality (Urenco European experience is that less than 10% of container enrichment is at product enrichment levels), and~~

~~(3) The container would have to interact (i.e., proximity limit not maintained) with greater than one component containing fissile material, as interaction of the container and one other component is subcritical.~~

~~For the uncontrolled accident sequence, conditions (1) through (3) above, above must be met to result in a potential criticality event. For this accident sequence, a criticality event was assumed. A criticality event is assumed to result in a high consequence to the worker and public.~~

~~For the controlled accident sequence, the preventive measure is administratively restrict proximity of vessels in non-designed locations containing enriched uranic material to ensure subcritical configuration by verifying, prior to moving a container containing enriched uranic material within 180 cm of the associated storage array, associated storage array condition is acceptable for storage of the container and no component containing enriched uranic material is in movement in the designated area (IROFS14b). If the acceptance criteria are not met, then the associated container shall not be moved.~~

~~The frequency index number for the initiating event was determined to be (-2). The NUREG-1 520 criteria - no failures of this type in this facility in 30 yrs - applies. This failure frequency index was selected based on evidence from history of similarly designed Urenco European plants, which have a combined plant history of greater than 30 yrs, and have not had a failure of this type.~~

~~A failure probability index of (-3) was selected for IROFS14b. This corresponds to an enhanced administrative IROFS per NUREG-1520. IROFS14b is enhanced by requiring independent verification of the IROFS safety function. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.~~

Table 4.1-5 Transitional Accident Sequence Descriptions

Accident Identifier: TVR1 -3

The accident sequence is the combination of numerous conditions assumed to lead to a criticality in a container being stored. This description of this sequence is the following:

(1). The fissile material in the container and interacting components, would be a uranvl fluoride/water mixture at an HIU atomic ratio near optimum moderation,

(2). The container, as well as other interacting components, would be nearly or completely filled with the above material at a high enough enrichment to achieve a configuration favorable for criticality (Urenco European experience is that less than 10% of container enrichment is at product enrichment levels), and

(3). The container would have to interact (i.e., proximity limit not maintained) with greater than one component containing fissile material, as interaction of the container and one other component is subcritical.

For the uncontrolled accident sequence, conditions (1) through (3) above, above must be met to result in a potential criticality event. For this accident sequence, a criticality event was assumed. A criticality event is assumed to result in a high consequence to the worker and public.

For the controlled accident sequence, the preventive measure is administratively restrict proximity of vessels in non-designed locations containing enriched uranic material to ensure subcritical configuration by verifying, prior to moving a container containing enriched uranic material within 180 cm of the associated storage array, associated storage array condition is acceptable for storage of the container and no component containing enriched uranic material is in movement in the designated area (IROFS14b). If the acceptance criteria are not met, then the associated container shall not be moved.

The frequency index number for the initiating event was determined to be (-2). The NUREG-1 520 criteria - no failures of this type in this facility in 30 vrs - applies. This failure frequency index was selected based on evidence from history of similarly designed Urenco European plants, which have a combined plant history of greater than 30 vrs, and have not had a failure of this type.

A failure probability index of (-3) was selected for IROFS14b. This corresponds to an enhanced administrative IROFS per NUREG-1520. IROFS14b is enhanced bv requiring independent verification of the IROFS safetv function. The IROFS justification for enhanced administrative control is discussed in Section 3.8.3.

Enclosure 2

Clean copy of the Integrated Safety Analysis Summary, Revision 19

urenco

INTEGRATED SAFETY ANALYSIS SUMMARY

Revision 19

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Summary of Changes for Revision 18		
Issue / Date	**Change**	**Description of Change**
18a 12-15-10	LBDCR-10-0110 11-03-10	Additional weighing system for receipt of feed cylinders on UBC pad. CC-MS-2010-0012; 70.72 = 2010-0708
	LBDCR-10-0095 11-03-10	Revise accident sequences to include the entire CRDB inventory and take credit for IROFS. CC-EG-2010-0291; 70.72 = 2010-0575
	LBDCR-10-0049 11-18-10	Clarify the GEVS charcoal filter testing CC-EG-2010-0113; 70.72 = 2010-0747
	LBDCR-10-0112 12-06-10	Restore IROFS as Sole IROFS for accident identifier EE-SEISMIC-SBM CC-LS-2010-0030; 70.72= 2010-0640
18b 01-06-11	LBDCR-10-0117 12-15-10	Add coil doors to SBM1001 First floor CC-EG-2010-0372; 70.72 = 2010-0806
	LBDCR-10-0103 10-08-10	Remove NRC Branch Technical Positions from the Code of Record table that were never issued CC-EG-2010-0324; 70.72= 2010-0821
	LBDCR-10-0116 01-03-11	Table 3.0-1 Updated to show AWS D1.1 2006 as the CRDB welding code of record & remove SAR from the "Source Document" column for both AWS D1.1 2000 and 2006. CC-EG-2010-0376; 70.72 = 2010-0803
19 01-06-11	N/A	Submittal to NRC for non substantial changes previously approved by LES

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1.0 PURPOSE

The purpose of this document, the National Enrichment Facility (NEF) Integrated Safety Analysis (ISA) Summary, is to provide a synopsis of the results of the NEF ISA, including the information specified in 10 CFR 70.65(b) (CFR, 2003a). An ISA identifies potential accident sequences in facility operations, designates items relied on for safety (IROFS) to either prevent such accidents or mitigate their consequences to an acceptable level, and describes management measures to provide reasonable assurance of the availability and reliability of IROFS. The NEF ISA Summary principally differs from the NEF ISA by focusing on higher risk accident sequences with consequences that could exceed the performance criteria of 10 CFR 70.61 (CFR, 2003b).

1.0.1 References

CFR, 2003a. Title 10, Code of Federal Regulations, Section 70.65, Additional content of applications, 2003.

CFR, 2003b. Title 10, Code of Federal Regulations, Section 70.61, Performance requirements, 2003.

2.0 SCOPE

The following information, as a minimum, is included in the National Enrichment Facility (NEF) Integrated Safety Analysis (ISA) Summary.

1. A general description of the site with emphasis on those factors that could affect safety (e.g., meteorology, seismology).

2. A general description of the facility with emphasis on those areas that could affect safety, including an identification of the controlled area boundaries.

3. A description of each process analyzed in the ISA, the hazards that were identified in the ISA, and a general description of the types of accident sequences.

4. Information that demonstrates compliance with the performance requirements of 10 CFR 70.61 (CFR, 2003a), including a description of the management measures, the requirements for criticality monitoring and alarms in 10 CFR 70.24 (CFR, 2003b), and the requirements of 10 CFR 70.64 (CFR, 2003c).

5. A description of the team, qualifications, and the methods used to perform the ISA.

6. A list briefly describing each item relied on for safety in sufficient detail to understand their functions in relation to the performance requirements of 10 CFR 70.61 (CFR, 2003a).

7. A description of the proposed quantitative standards used to assess the consequences to an individual from acute chemical exposure to licensed material or chemicals produced from licensed materials which are on-site, or expected to be on-site.

8. A descriptive list that identifies all items relied on for safety that are the sole item preventing or mitigating an accident sequence that exceeds the performance requirements of 10 CFR 70.61 (CFR, 2003a).

9. A description of the definitions of unlikely, highly unlikely, and credible as used in the evaluations in the ISA.

2.0.1 References

CFR, 2003a. Title 10, Code of Federal Regulations, Section 70.61, Performance requirements, 2003.

CFR, 2003b. Title 10, Code of Federal Regulations, Section 70.24, Criticality accident requirements, 2003.

CFR, 2003c. Title 10, Code of Federal Regulations, Section 70.64, Requirements for new facilities or new processes at existing facilities, 2003.

3.0 APPLICABLE REQUIREMENTS / GUIDANCE

3.0.1 Regulatory Requirements/Guidance

The requirement to prepare and submit an Integrated Safety Analysis (ISA) Summary for Nuclear Regulatory Commission (NRC) approval is stated in 10 CFR 70.65(b) (CFR, 2003a). 10 CFR 70.65(b) (CFR, 2003a) also describes the contents of an ISA Summary. The ISA Summary has been developed following the guidance of NUREG-1520 which meets the format, structure, and content of an ISA Summary that is consistent with the requirements of 10 CFR 70 (CFR, 2003b).

The information provided in the ISA Summary, the corresponding regulatory requirement, and the section of NUREG-1520, Chapter 3 in which the NRC expectations for such information are presented are summarized below.

Information Category and Requirement	**10 CFR 70 Citation**	**NUREG-1520 Chapter 3 Reference**
Section 3.1 General Information		
• ISA methodology description	70.65(b)(5)	3.4.3.2(5)
• ISA Team description	70.65(b)(5)	3.4.3.2(5)
• Quantitative standards for acute chemical exposures	70.65(b)(7)	3.4.3.2(7)
• Definition of terms	70.65(b)(9)	3.4.3.2(9)
• Compliance with baseline design criteria and criticality monitoring and alarms	70.64 & 70.65(b)(4)	3.4.3.2(4D) 3.4.3.2(4C)
• Safety Program commitments	70.62(a)	3.4.3.1
Section 3.2 Site Description		
• Site description	70.65(b)(1)	3.4.3.2(1)
Section 3.3 Facility Description		
• Facility and Major Civil Structural Descriptions	70.65(b)(2)	3.4.3.2(2)
Section 3.4 Enrichment and Other Process Descriptions		
• Description of processes analyzed	70.65(b)(3)	3.4.3.2(3)
Section 3.5 Utility and Support Systems		
• Description of support systems analyzed	70.65(b)(3)	3.4.3.2(3)
Section 3.6 Process Hazards		
• Identification of hazards	70.65(b)(3)	3.4.3.2(3)
Section 3.7 Accident Sequences		
• General types of accident sequences	70.65(b)(3)	3.4.3.2(3)
• Risk ranking	70.65(b)(3)	3.4.3.2(3)
• Characterization of intermediate and high-risk accident sequences	70.65(b)(3)	3.4.3.2(3)
Section 3.8 Items Relied on For Safety (IROFS)		
• List and descriptions of IROFS at the system level	70.65(b)(6)	3.4.3.2(6)
• IROFS management measures	70.65(b)(4)	3.4.3.2(4B) 3.4.3.2(6)
• Sole IROFS	70.65(b)(8)	3.4.3.2(8)

3.0.2 Applicable Codes, Standards, and NRC Documents

The following approach will be used with Codes, Standards, and NRC Documents:

1) When the edition year of Codes, Standards, and NRC Documents are listed in the License Basis Documents, that edition year will be used.

2) Applicable portions of Codes, Standards, and NRC Documents referenced in the License Basis Documents (Parent Codes) will be followed in the manner they are invoked with the exception that the edition of Codes, Standards, Specifications, etc cited within the Parent Codes (i.e. Daughter Codes) will be the year listed in the Parent Code or a more current edition. Editions of Daughter Codes that are older than the edition referenced by the Parent Code may be used if a code reconciliation is performed, and the outcome of the reconciliation will support a license update through the 70.72(c) process without prior NRC approval.

It is not practical to refer to a specific edition of each code, standard, NRC document, etc throughout the text of the License Basis Documents. Instead, the approved edition of each reference that is committed to in the License Basis Documents and that is applicable to the design, construction, or operation of the NEF is listed in Table 3.0-1 and Table 3.0-2. Should there be a conflict between the edition listed in the table and a reference elsewhere in the License Basis Documents, the edition in the table shall govern.

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ACI	117	1990 (Reaffirmed 2002)	Standard Tolerances for Concrete Construction and Materials	SAR ISAS
ACI	318	2002	Building Code Requirements for Structural Concrete	SAR ISAS SER
ACI	349	2001	Code Requirements for Nuclear Safety Related Concrete Structures	SAR ISAS SER
AEAT		1998 Version 8A	MONK: A Monte Carlo Program for Nuclear Criticality Safety and Reactor Physics Analyses	SER
AISC	M016	1989 9th Edition w/ Supplement 1 [Supplement No. 1 also known as AISC 335-89s1, Supp. No. 1 to the Specification for Structural Steel Buildings]	Manual of Steel Construction - Allowable Stress Design, and Supplement No. 1	SAR ISAS SER
AISC/ANSI	N690	1994 (2004) w/ Supplement No. 2	Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities	ISAS SAR
AMCA	Pub. 210	1999	Laboratory Methods of Testing Fans for Aerodynamic Performance Ratings	SAR ISAS
AMCA	Pub. 261	1998	Directory of Products Licensed to Use the AMCA Certified Ratings Seal	SAR ISAS
AMCA	Pub. 99	1986	Standards Handbook (Contains the following AMCA Standards: 99-0021-01 The Fan Laws 99-0066-01 The AMCA Vocabulary: Definitions 99-0068-03 The AMCA Vocabulary: Product Definitions, etc...)	SAR ISAS
ANSI	N13.11	1983	Dosimetry - Personnel Dosimetry Performance - Criteria for Testing	SAR
ANSI	N13.15	1985	Radiation Detectors - Personnel Thermo luminescence Dosimetry Systems - Performance	SAR

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ANSI	N13.27	1981	Performance Requirements for Pocket-Sized Alarm Dosimeters and Alarm Ratemeters	SAR
ANSI	N13.6	1966(Reaffirmed 1989)	Practice for Occupational Radiation Exposure Records Systems	SAR
ANSI	N14.1	2001 (Note: above edition is for cylinder pressure testing and valve replacement / installation) Version in effect at the time of cylinder manufacture (Note: above edition is for all other aspects related to transport cylinders)	Uranium Hexafluoride - Packaging for Transport	SAR ISAS ER FNMCP SER
ANSI	N15.5	1972	Statistical Terminology and Notation for Nuclear Materials Management	SAR ISAS FNMCP
ANSI	N323	1978	Radiation Protection Instrumentation Test and Calibration	SAR
ANSI	Z88.2	1992	Practices for Respiratory Protection	SAR
ANSI/ANS	3.1	1993	Selection, Qualification, and Training of Personnel for Nuclear Power Plants	SER SAR
ANSI/ANS	3.2	1994	Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants	ISAS SAR SER
ANSI/ANS	8.10	1983 (Reaffirmed 2005)	Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement	SAR SER
ANSI/ANS	8.1	1998 (Note: additional requirements to this edition code are required per section 5.3.2 of SER)	Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors	SER SAR
ANSI/ANS	8.12	1993	Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors	SER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ANSI/ANS	8.15	1995	Nuclear Criticality Control of Special Actinide Elements	SER
ANSI/ANS	8.17	1997	Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors	SER
ANSI/ANS	8.19	1996	Administrative Practices for Nuclear Criticality Safety	SAR SER
ANSI/ANS	8.20	1991	Nuclear Criticality Safety Training	SAR SER
ANSI/ANS	8.21	1995	Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors	SER
ANSI/ANS	8.22	1997	Nuclear Criticality Safety Based on Limiting and Controlling Moderators	SAR SER
ANSI/ANS	8.23	1997	Nuclear Criticality Accident Emergency Planning and Response	SER
ANSI/ANS	8.3	1997	Criticality Accident Alarm System	ISAS SER
ANSI/ANS	8.5	1996	Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Materials	SER
ANSI/ANS	8.6	1995	Safety in Conducting Sub critical Neutron-Multiplication Measurements in Situ	SER
ANSI/ANS	8.7	1998	Guide for Nuclear Criticality Safety in the Storage of Fissile Materials	SAR SER
ANSI/ANS	8.9	1987 (Reaffirmed 1995)	Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials	SER SAR
ANSI/ARI	410	2001	Forced-Circulation Air-Cooling Air-Heating Coils	SAR ISAS
ANSI/ASME	N509	1989 (Reaffirmed 1996)	Nuclear Power Plant Air-Cleaning Units and Components	SAR ISAS
ANSI/ASME	N510	1989 (Reaffirmed 1995)	Testing of Nuclear Air Treatment Systems	SAR ISAS
ANSI/AWS	D1.1	2000	Structural Welding Code – Steel	ISAS
ANSI/AWS	D1.1	2006 (Note: Applied to ETC cascade steelwork and CRDB)	Structural Welding Code – Steel	ISAS

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ANSI/AWS	D1.3	Version in effect at time of manufacture	Structural Welding Code – Seet Steel	SAR ISAS
ANSI/AWS	D9.1	2000	Sheet Metal Welding Code	SAR ISAS
ANSI/HPS	N13.1	1999	Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities	SAR SER
ANSI/HPS	N13.22	1995	Bioassay Program for Uranium	SAR
ANSI/HPS	N13.30	1996	Performance Criteria for Radio bioassay	SAR
ANSI/ICC	A117.1	1998 (Note: only applicable to select buildings)	Accessible and Usable Buildings and Facilities	Letter to Mr. Krich from Fermin Aragon April 25, 2006
ANSI/IEEE	279	1971	Criteria for Protection Systems for Nuclear Power Generating Stations	ISAS SER SAR
ANSI/IEEE	383	1974 (R1992)	IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices and Connections for Nuclear Power Generating Stations	ISAS SAR
ANSI/IEEE	C2	2002	National Electrical Safety Code	SAR ISAS
ANSI/ISA	S67.04	1994	Setpoints for Nuclear Safety-Related Instrumentation	SAR
AREVA / LES		2006 Rev. 3	MONK8A Validation and Verification	SAR SER
ARI	430	1980	Standard for Central Station Air-Handling Units	SAR ISAS
ASCE	4	1998	Seismic Analysis of Safety Related Nuclear Structures	ISAS

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ASCE	7-02 (Note: Excluding Load Combinations for Safety Significant Steel Structures) 7-98 (Note: Load Combinations for Safety Significant Steel Structures Only)	2003 (7-02, see note to the left) 2000 (7-98, see note to the left)	Minimum Design Loads for Building and Other Structures	SAR ISAS SER
ASCE	43	2005	Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities & Commentary	ISAS SAR SER
ASCE	58	1980	Structural Analysis and Design of Nuclear Plant Facilities Manuals and Reports on Engineering Practice	SAR ISAS SER
ASHRAE	51	1999	Laboratory Methods of Testing Fans for Aerodynamic Performance Ratings	SAR ISAS
ASHRAE		2000	Systems and Equipment 2000	SAR ISAS
ASME	AG-1	1997	Code on Nuclear Air and Gas Treatment	SAR ISAS
ASME	B&PV Section VIII Division 1	Current Edition at Time of Detailed Component Design	Boiler and Pressure Vessel Code, Section VIII, Division 1	FNMCP SAR ISAS SER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ASME	B31.3	2002 (For Utility and Support Systems, e.g. Balance of Plant) Current Edition at Time of Detail Design (For Process Piping, e.g. UF6 Feed System, Cascade System, Product Take-off System, Tails Take-off System, Product Blending System, Product Liquid Sampling System, Contingency Dump System)	Process Piping	ISAS SAR
ASME	NQA-1 Part I -All (incl. all supplements) Part II -Subpart 2.7 only Part III -None	1994 with 1995 addenda	Quality Assurance Requirements for Nuclear Facilities Applications w/ 1995 addenda Part I: Basic Requirements and Supplementary Requirements for Nuclear Facilities Part II: Quality Assurance Requirements for Nuclear Facility Applications Subpart 2.7: Quality Assurance Requirements of Computer Software for Nuclear Facility Applications Part III: Nonmandatory Appendices	SAR ISAS SER Material License QAPD
ASNT	SNT-TC-1A	December 1988	Personnel Qualification and Certification in Nondestructive Testing Practice No. SNT-TC-1A, from Part 1 of Supplement 2S-2 of NQA-1a-1995	QAPD
ASTM	C761	2001	Standard Test Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear, and Radiochemical Analysis of Uranium Hexafluoride	SAR ISAS FNMCP

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ASTM	C787	2003	Standard Specification for Uranium Hexafluoride for Enrichment	SAR SER FNMCP
ASTM	C986	1989	Developing Training Programs in the Nuclear Fuel Cycle	SAR
ASTM	D6646	October 2003	Standard Test Method for Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Palletized Activated Carbon	SAR ISAS
ASTM	E1168	1995	Radiological Protection Training for Nuclear Facility Workers	SAR
ASTM	E1686	2002	Standard Guide for Selection of Environmental Noise Measurements and Criteria	ER
ASTM	E814	2002	Standard Test Method for Fire Tests of Through-Penetration Fire Stops	SAR ISAS
Bowles		1996	Foundation Analysis and Design	SAR ISAS
CGA	Publication G-7.1	1997	Commodity Specification for Air	SAR
CSA	C22.2 NO 0.3-01	March 2001 (R2005) 6th Edition: General Instruction No1; Update No 2	Test Methods for Electrical Wires and Cables	SAR ISAS
DOE	ERDA 76-21	1976	Nuclear Air Cleaning Handbook	SAR ISAS
DOE	STD-1020	January 2002	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities	SAR ISAS SER
EPA	520/1-88-020	1988	Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11	ER SER
EPA	550/9	1973	Public Health and Welfare Criteria for Noise	ER
EPRI	NP-5652	1988	Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Grade Applications	Material License
EPRI	NP-6074	1988	Engineering Estimates of Earthquake Ground Motion for Eastern North America	ISAS

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
EPRI	TR-102323	1996	Guidelines for the Electromagnetic Interference Testing in Power Plants	Material License
EPRI	TR-106439	1996	Guideline on Evaluation and Acceptance of Commercial Grade Digital Equipment for Nuclear Safety Applications	Material License
HNM		2003	NEF Memorandum of Understanding dated December 30, 2003, from T. Woomer, Director of Utilities - City of Hobbs, New Mexico, to J.L. Shaw, Lockwood Greene	ER
HUD	HUD-953-CPD	1985	The Noise Guidebook, U.S. Department of Housing and Urban Development	ER
IAPMO	UMC	2003 (Note: follow UMC 2003 as amended by NMAC NMMC, 2003)	Uniform Mechanical Code	SAR ISAS
IAPMO	UPC	2003 (Note: follow UPC 2003 as amended by NMAC NMPC, 2003) (Note: 100-Year 1-Hr Rain event should not be based on UPC. It should be based on the Rain Load section of SER section 3.3.1.2.2.2)	Uniform Plumbing Code	SAR ISAS
ICC	IBC	2003 (Note: follow IBC 2003 as amended by NMAC NMCBC, 2003)	International Building Code	SAR ISAS SER
ICC	IECC	2003 (Note: follow IECC 2003 as amended by NMAC NMECC, 2003)	International Energy Conservation Code	NMAC NMECC
ICC	IFC	2003	International Fire Code	ISAS SAR

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
ICEA	T-30-520	1986	Vertical Cable Tray Flame Tests @ 70,000 Btu	SAR ISAS
IEEE	323	1983	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	SAR ISAS SER
IEEE	336	1991	Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities	SAR ISAS
IEEE	338	1987	IEEE Standard Criteria for Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems	SAR
IEEE	344	1987	IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	SAR
IEEE	384	1992	IEEE standard Criteria for Independence of Class IE Equipment and Circuits	SAR
IEEE	518	1982	IEEE Guide for Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources	SAR
IEEE	603	1998	IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations	SER SAR
IEEE	1050	1996	IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations	SAR
IEEE	1202	1991	IEEE Standard for Flame Testing of Cables for Use in Cable tray in Industrial and Commercial Occupancies	SAR
ISO	668	1995	Series 1 Freight Containers - Classification, Dimensions and Ratings	SAR ISAS
ISO	14644-1	May 1999	Clean rooms and associated controlled environments - Part 1: Classification of air cleanliness	SAR ISAS
LG		2004	National Enrichment Facility (NEF) Memorandum of Understanding dated January 21, 2004, from J.L. Shaw, Lockwood Greene, to J.D. Brown, Mayor Eunice, New Mexico	ER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NAVFAC	DM-7.01	1986	Soil Mechanics	ISAS SAR SER
NAVFAC	DM-7.02	1986	Foundations and Earth Structures	ISAS SAR SER
NCRP	Rpt. No. 59	1978	Operational Radiation Safety Program, Report No. 59 National Council on Radiation Protection and Measurements	SAR
NEMA	MG 1	1998 Rev. 3	Motors and Generators	SAR ISAS
NFPA	1	1997	Fire Prevention Code	SAR ISAS
NFPA	10	1998	Portable Fire Extinguishers	SAR ISAS SER
NFPA	12	2000	Carbon Dioxide Systems	SAR ISAS SER
NFPA	13	1999	Installation of Sprinkler Systems	SAR ISAS SER
NFPA	14	2000	Standard for the Installation of Standpipe, Private Hydrants and Hose Systems	SAR ISAS
NFPA	15	1996	Water Spray Fixed Systems for Fire Protection	SAR ISAS
NFPA	20	1999	Installation of Stationary Pumps	SAR ISAS SER
NFPA	22	1998	Standard for Water Tanks for Private Fire Protection	SAR ISAS SER
NFPA	24	1995	Private Fire Service Mains and Their Appurtenances	SAR ISAS

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NFPA	25	1998	Water Based Fire Protection Systems	SAR ISAS
NFPA	30	2003	Flammable and Combustible Liquids Code	SAR ISAS
NFPA	54	2002 (Note: follow NFPA 54 2002 as amended by NMAC NMLPG, 2006)	National Fuel Gas Code	SAR ISAS
NFPA	55	1993	Compressed & Liquefied Gases in Cylinders	SAR ISAS
NFPA	58	2001	Liquefied Petroleum Gas Code	SAR ISAS
NFPA	70	2005 (Note: follow NFPA 70 2005 as amended by NMAC NMEC, 2005)	National Electric Code	NMAC NMEC
NFPA	72	1999	National Fire Alarm Code	SAR ISAS SER
NFPA	75	1995	Electronic Computer/Data Processing Systems	SAR ISAS
NFPA	79	1997	Electrical Standard for Industrial Machinery	SAR ISAS
NFPA	80	1999	Standard for Fire Doors and Fire Windows	SAR ISAS
NFPA	91	1995	Exhaust Systems for Air Conveying of Materials	SAR ISAS
NFPA	110	2002	Standard for Emergency and Standby Power Systems	SAR ISAS
NFPA	111	2001	Standard on Stored Electrical Energy Emergency and Standby Power Systems	SAR ISAS
NFPA	220	1999 (Note: Construction Classification will also meet NMAC NMCBC, 2003 requirements)	Standard on Types of Building Construction	SAR ISAS SER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NFPA	221	1997	Standard for Fire Walls and Fire Barrier Walls	SAR ISAS
NFPA	232	1986	Standard for the Protection of Records	QAPD
NFPA	251	1995	Standard Methods of Tests of Fire Endurance of Building Construction and Materials	SAR
NFPA	600	1996	Standard on Industrial Fire Brigades	SAR ISAS SER
NFPA	704	2001	Standard System for the Identification of the Hazards of Materials for Emergency Response	SAR ISAS
NFPA	780	1997	Standard for the Installation of Lightning Protection Systems	SAR ISAS
NFPA	801	2003	Standard for Fire Protection for Facilities Handling Radioactive Materials	SAR ISAS SER
NFPA	1410	2000	Standard on Training for Emergency Scene Operations	SAR SER
NFPA	2001	2000	Standard on Clean Agent Fire Extinguishing Systems	SAR ISAS SER
NFPA	5000	2003	Building Construction and Safety Code	SAR ISAS
NFPA	232AM	1986	Archives and Record Center	QAPD
NFPA	70E	2004	Standard for Electrical Safety in the Workplace	Letter to Mr. Krich from Fermin Aragon April 25, 2006 SAR ISAS SER
NFPA	80A	1993	Exterior Fire Exposures	SAR ISAS
NFPA	90A	2002	Standard for the Installation of Air Conditioning and Ventilating Systems	SAR ISAS

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NFPA	90B	2002	Standard for the Installation of Warm Air Heating and Air Conditioning Systems	SAR ISAS
NFPA	Handbook	1997 18th Edition	Fire Protection Handbook Section 9, Chapter 30, Nuclear Facilities	SAR ISAS
NMAC	20.2.72	Latest Edition	Construction Permits	ER
NMAC	20.2.73	Latest Edition	Notice of Intent and emissions inventory requirements	ER
NMAC	20.2.78	2002	Air Quality Emission Standards for Hazardous Air Pollutants	ER
NMAC	20.3.2	November 2001	Radiation Protection, Registration of Radiation Machines and Services	ER
NMAC	20.4.1	2000	Hazardous Waste Management	ER
NMAC	NMCBC, 14.7.2	2003 (Note: Adopts and Amends IBC, 2003)	New Mexico Commercial Building Code	SAR ISAS
NMAC	NMEC, 14.10.4	2005 (Note: Adopts and Amends NFPA 70, 2005)	New Mexico Electric Code	SAR ISAS
NMAC	NMECC, 14.7.6	2003 (Note: Adopts and Amends IECC, 2003)	New Mexico Energy Conservation Code	Letter to Mr. Krich from Fermin Aragon April 25, 2006
NMAC	NMLPG, 19.15.40	February 2006	New Mexico Liquid Petroleum Gas Standard	Letter to Mr. Krich from Fermin Aragon April 25, 2006
NMAC	NMMC, 14.9.2	2003 (Note: Adopts and Amends UMC, 2003)	New Mexico Mechanical Code	Letter to Mr. Krich from Fermin Aragon April 25, 2006 NMAC NMCBC

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NMAC	NMPC, 14.8.2	2003 (Note: Adopts and Amends UPC, 2003) (Note: 100-Year 1-Hr Rain event should not be based on NMPC. It should be based on the Rain Load section of SER section 3.3.1.2.2.2)	New Mexico Plumbing Code	Letter to Mr. Krich from Fermin Aragon April 25, 2006 NMAC NMCBC
NMAC	NMWQCC20.6.2	2002	Ground and Surface Water Protection(Note: NMAC 20.6.2.3103 requires Standards for Groundwater of 10,000mg/L TDS Concentrations or Less)	ER
NMAC	NMWQCC 20.6.4	2002	Standards for Interstate and Intrastate Surface Waters	ER
NRC	Branch Position	April 1993	Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material, Branch Technical Position	SAR SER
NRC	Branch Position	1997 Rev. 4	HICB-11, Guidance on Application and Qualifications of Isolation Devices (Chapter 7, BTP 7-11 of NUREG 0800)	SAR
NRC	Branch Position	1997 Rev. 4	HICB-17, Guidance on Self-Test and Surveillance Test Provisions (Chapter 7, BTP 7-17 of NUREG 0800)	SAR
NRC	Bulletin 2003-03	August 2003	Potentially Defective 1-Inch Valves for Uranium Hexafluoride Cylinders	SAR ISAS
NRC	Information Notice 94-23	1994	Guidance to Hazardous, Radioactive, and Mixed-Waste Generators on the Elements of a Waste Minimization Program	SER
NRC	NUREG/BR-0006	2009	Instructions for completing Nuclear Material Transaction Reports and Concise Note Forms.	FNMCP

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Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NRC	NUREG/BR-0007	2009	Instructions for Completing Material Balance Report and Physical Inventory Listing	FNMCP
NRC	NUREG/BR-0096	1992	Instructions and Guidance for Completing Physical Inventory Summary Reports	FNMCP
NRC	NUREG/CR-0098	1978	Development of Criteria for Seismic Review of Selected Nuclear Power Plants	SER
NRC	NUREG/CR-1071	September 1980	Critical Experiments with Interstitially-Moderated Arrays of Low-Enriched Uranium Oxide	SAR
NRC	NUREG/CR-2078	1983	Handbook of Nuclear Safeguards Measurement Methods	FNMCP
NRC	NUREG/CR-2919	1982	XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations	ER
NRC	NUREG/CR-5659	1990	Control Room Habitability System Review Models	SER
NRC	NUREG/CR-5734	1991	Recommendations to the NRC on Acceptable Standard Format and Content for the FNMC Plan Required for Low-Enriched Uranium Enrichment Facilities	FNMCP
NRC	NUREG/CR-6331	1997	Atmospheric Relative Concentrations in Building Wakes	SER
NRC	NUREG/CR-6410	March 1998	Nuclear Fuel Cycle Facility Accident Analysis Handbook	ISAS SAR SER
NRC	NUREG/CR-6698	2001	Guide for Validation of Nuclear Criticality Safety Calculational Methodology	SAR SER
NRC	NUREG-0700	2002	Human-System Interface Design Review Guidelines	SAR ISAS SER Material License
NRC	NUREG-0711	2004	Human Factors Engineering Program Review Model	SAR ISAS SER Material License

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Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NRC	NUREG-0800 Section 3.8.5, Section 3.5.1.6, and Section 3.3.2	1981	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants	SER ISAS
NRC	NUREG-1140	1988	A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees	SER SAR
NRC	NUREG-1391	1991	Chemical Toxicity of Uranium Hexafluoride Compared to Acute Effects of Radiation	SAR SER
NRC	NUREG-1400	1993	Air Sampling in the Workplace	SAR SER
NRC	NUREG-1513	2001	Integrated Safety Analysis Guidance Document	SER SAR
NRC	NUREG-1520	2002	Standard Review Plan for the Review of a License Application For A Fuel Cycle Facility	SAR ISAS SER ER
NRC	NUREG-1601	August 1997	Chemical Process Safety at Fuel Cycle Facilities	SAR
NRC	NUREG-1887	2007	RASCAL 3.0.5: Description of Models and Methods	SER
NRC	NUREG-1748	2003	Environmental Review Guidance for Licensing Actions Associated with NMSS Programs, Final Report	SAR ER
NRC	NUREG-1757	2003	Consolidated NMSS Decommissioning Guidance - Financial Assurance, Recordkeeping and Timelines	SAR SER
NRC	NUREG-6410	1998	Nuclear Fuel Cycle Facility Accident Analysis Handbook	SER
NRC	Regulatory Guide 1.100	1988	Seismic Qualification of Electric and Mechanical Equipment for Nuclear Power Plants	SAR
NRC	Regulatory Guide 1.105	1999	Set points for Safety-Related Instrumentation	SAR ISAS SER
NRC	Regulatory Guide 1.109	1977 Rev. 1	Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10 CFR Part 50, Appendix I	ER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NRC	Regulatory Guide 1.111	1977 Rev. 1	Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors	ER
NRC	Regulatory Guide 1.118	1995	Periodic Testing of Electric Power and Protection Systems	SAR
NRC	Regulatory Guide 1.140	June 2001 Rev. 2	Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units for Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants	SAR ISAS
NRC	Regulatory Guide 1.152	1996	Criteria for Digital Computers in Safety Systems in Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.168	2004	Verification, Validation, Reviews, and Audits for Digital Software Used in Safety Systems of Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.169	1997	Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.170	1997	Software Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.172	1997	Software Requirements Specifications for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.173	1997	Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants	Material License
NRC	Regulatory Guide 1.180	2003	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems	SAR ISAS SER
NRC	Regulatory Guide 1.198	2003	Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites	SER SAR ISAS
NRC	Regulatory Guide 1.75	1978 Rev. 2	Physical Independence of Electric Systems	SAR

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NRC	Regulatory Guide 1.91	1978	Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants	SER
NRC	Regulatory Guide 3.17	1974	Earthquake Instrumentation for Fuel Reprocessing Plants	SAR
NRC	Regulatory Guide 3.67	1992	Standard Format and Content of Emergency Plans for Fuel Cycle and Materials Facilities	SAR SER
NRC	Regulatory Guide 3.71	1998	Nuclear Criticality Safety Standards for Fuels and Materials Facilities	SAR ISAS SER
NRC	Regulatory Guide 4.15	1979 Rev. 1	Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment	ER
NRC	Regulatory Guide 4.16	1985	Monitoring and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Gaseous Effluents from Nuclear Fuel Processing and Fabrication Plants and Uranium Hexafluoride Production Plants	SAR ISAS SER
NRC	Regulatory Guide 5.15	1997	Tamper-Indicating Seals for the Protection and Control of Special Nuclear Material	FNMCP
NRC	Regulatory Guide 8.10	1977	Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable	SAR SER
NRC	Regulatory Guide 8.13	June 1999 Rev. 3	Instruction Concerning Prenatal Radiation Exposure	SAR
NRC	Regulatory Guide 8.15	October 1999	Acceptable Programs for Respiratory Protection	SAR
NRC	Regulatory Guide 8.2	1973	Guide for Administrative Practice in Radiation Monitoring	SAR SER
NRC	Regulatory Guide 8.24	1979	Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication	SAR SER
NRC	Regulatory Guide 8.25	1992	Air Sampling in the Workplace	SAR SER
NRC	Regulatory Guide 8.29	February 1996	Instructions Concerning Risks from Occupational Radiation Exposure	SAR
NRC	Regulatory Guide 8.34	1992	Monitoring Criteria and Methods To Calculate Occupational Radiation Doses	SAR SER

Table 3.0-1 NEF Licensing Code of Record

Code Group / Reference	Code Number	Year or Edition	Title	Source Document
NRC	Regulatory Guide 8.37	1993	ALARA Levels for Effluents from Materials Facilities	SAR SER
NRC	Regulatory Guide 8.4	February 1973	Direct-Reading and Indirect-Reading Pocket Dosimeters,	SAR
NRC	Regulatory Guide 8.7	1992	Instructions for Recording and Reporting Occupational Radiation Exposure Data	SAR SER
NRC	Regulatory Guide 8.9	July 1993 Rev.1	Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program	SAR
PCI	MNL-120	1999 5th Edition	Precast Concrete Institute Design Handbook: Precast and Prestressed Concrete	SAR ISAS
UL	83	February 2008 14th Edition	UL Standard for Safety Thermoplastic-Insulated Wires and Cables	SAR ISAS
UL	508A	December 2007 1st Edition	UL Standard for Safety Industrial Control Panels	SAR ISAS
UL	586	December 1996 8th Edition	Standard for High-Efficiency Particulate, Air Filter Units	SAR
UL	900	2004	Standard for Air Filter Units	SAR
UL	1063	December 2006 7th Edition	UL Standard for Safety Machines Tool Wires and Cables	SAR ISAS
UL	1277	November 2001 4th Edition	Standard for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members	SAR
UL	1479	May 2003 3rd Edition	Fire Tests of Through-Penetration Fire Stops	SAR
UL	1581	July 2008 4th Edition	UL Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords	SAR ISAS
UL	1685	December 2007 3rd Edition	UL Standard for Safety Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables	SAR ISAS
Winterkorn		1975	Foundation Engineering Handbook	SER SAR ISAS

Table 3.0-2 NEF Licensing Code Cases of Record

Code Case	Code No	Code Requirement	Code Case Alternative	Source Document
ASME Code Case 2211-1	ASME B&PV Section VIII Division 1, paragraph UG-125(a)	All pressure vessels within the Scope of this Division, irrespective of size or pressure, shall be provided with pressure relief devices in accordance with the requirements of UG-125 through UG-137.	**Pressure Vessels With Overpressure Protection by System Design** Applied to the Product Liquid Sampling Autoclave pressure vessel, which is tested and stamped to the requirements of ASME Section VIII, Division 1 rules and is registered with the National Board. Per the requirements of ASME Code Case 2211-1, the autoclave may be provided with overpressure protection by system design in lieu of a pressure relief device because: (a) The autoclave's function is to provide a secondary barrier that is critical to preventing the release of hazardous fluids (HF, UO_2F_2). (b) The autoclave pressure vessel Code Data Report specifies overpressure protection by system design in lieu of pressure relief devices. (c) Analysis has been conducted of all credible scenarios that could result in an overpressure condition in the autoclave. In all cases the maximum allowable working pressure (MAWP) of the vessel is greater than the highest allowed postulated pressures. (d) Two independent and diverse automatic trips of the autoclave heaters and one fan motor are provided to eliminate the heat input and preclude approaching the autoclave design pressure. This is considered to be acceptable due to the large margin between the autoclave design pressure 12 bar (174 psia) and the maximum allowable working pressure 1.8 bar (26 psia) and the fail-safe design of the two independent and diverse automatic trips of the autoclave heaters and fan motor. The pressure vessel design is 12 bar (174 psia) absolute and the design temperature is 160°C (320°F). (e) The Code Data Record references this ASME Code Case.	SAR ISAS

Code Case	Code No	Code Requirement	Code Case Alternative	Source Document
ASME B31.3 Code Case 185	ASME B31.3	Process piping is required to be leak tested prior to initial operations. The baseline test method for internally pressurized piping systems is a hydrostatic leak test to be conduced at an internal pressure of 1.5 times the design pressure of the system.	The qualified helium leak test under vacuum conditions in ASME B&PV Code, Section V, Article 10, Appendix V and Appendix IX are acceptable substitutes for the testing requirements identified in para. 345 of ASME B31.3 provided the following conditions are met: 1. The piping system is expected to operator only under vacuum conditions. 2. Any leakage into the piping system that could result in an internal reaction that increases the pressure above atmospheric shall be prevented. 3. All system joints and connections shall be leak tested. Piping welds and joints to be tested shall be uninsulated and exposed, and shall not be primed, painted, or otherwise coated. 4. Helium leak testing is performed at vacuum conditions sufficient for mass spectrometer helium leak tests of ASME B&PV Code, Section V, Article 10, Appendices V and IX, or at pressures below 10 millibars absolute (<1% atmospheric pressure), whichever is lower. 5. ASME B31-3, para. 345.2 applies, except for the minimum "10 min" leak test period, the leak test pressure requirements and the limitation of the need for access for jacketed piping to "visual access." Para. 345.3 also applies except for the leak test pressure requirements. All other inspections, examination and records requirements of ASME B31.3 Chapter VI must still be satisfied. 6. Written procedures shall be qualified, in accordance with B&PV Code, Section V, Article 10. 7. Test personnel shall have training and certification consistent with ASME B31.3, para. 342. 8. Test reports, including records of personnel qualifications, shall meet the requirements of ASME B&PV Code, Section V, Article 10, Item T-1091 and shall be retained for at least 5 years. 9. Options of the ASME B&PV, Section V, Article 10 test methods, which allow the engineering design to modify specified requirements of the Appendix V and	SAR ISAS

Code Case	Code No	Code Requirement	Code Case Alternative	Source Document
			Appendix IX test methods, may only be exercised so as to make these requirements more sensitive or more conservative. 10. The use of the vacuum leak test instead of the pressurized leak test of ASME B31.3, para.345, shall be specified in the engineering design and shall be accepted by the Owner.	

3.0.3 References

Edition of Codes, Standards, NRC Documents, etc that are not listed below are given in Table 3.0-1.

CFR, 2003a. Title 10, Code of Federal Regulations, Section 70.65, Additional content of applications, 2003.

CFR, 2003b. Title 10, Code of Federal Regulations, Part 70, Domestic Licensing of Special Nuclear Material, 2003.

3.1 GENERAL INTEGRATED SAFETY ANALYSIS (ISA) INFORMATION

3.1.1 ISA Methods

This section outlines the approach utilized for performing the integrated safety analysis (ISA) of the process accident sequences. The approach used for performing the ISA is consistent with Example Procedure for Accident Sequence Evaluation, Appendix A to Chapter 3 of NUREG-1520. This approach employs a semi-quantitative risk index method for categorizing accident sequences in terms of their likelihood of occurrence and their consequences of concern. The risk index method framework identifies which accident sequences have consequences that could exceed the performance requirements of

10 CFR 70.61 (CFR, 2003c) and, therefore, require designation of items relied on for safety (IROFS) and supporting management measures. Descriptions of these general types of higher consequence accident sequences are reported in the ISA Summary.

The ISA is a systematic analysis to identify plant and external hazards and the potential for initiating accident sequences, the potential accident sequences, the likelihood and consequences, and the IROFS.

The hazard and operability (HAZOP) analysis method was used initially to identify hazard for the Uranium Hexafluoride (UF_6) process systems and Technical Services Building (TSB) systems. This method is consistent with the guidance provided in NUREG-1513. The choice of a particular method or combination of methods is dependent upon a number of factors including:

- Analysis problem characteristics
- Motivation for the study
- Perceived risk associated with the subject process or activity
- Resource availability and analyst/management preference
- Type of information available to perform the study
- Type of results needed

To satisfy NRC requirements as defined in Part 70, a method should be chosen that is capable of identifying specific accident/event sequences in addition to the safety controls that prevent such accidents or mitigate their consequences. The HAZOP method has this capability.

NUREG-1513 identifies several methods in addition to the HAZOP method (i.e., What-IF/Checklist and Failure Modes and Effects Analysis (FMEA)) that may be implemented. The guidance from NUREG 1513 will be followed for selection of a hazard analysis method.

The ISA Team reviewed the hazard identified for the "credible worst-case" consequences. All credible high or intermediate severity consequence accident scenarios were assigned accident sequence identifiers, accident sequence descriptions, and a risk index determination was made.

The risk index method is regarded as a screening method, not as a definitive method of proving the adequacy or inadequacy of the IROFS for any particular accident.

The tabular accident summary resulting from the ISA identifies, for each sequence, which engineered or administrative IROFS must fail to allow the occurrence of consequences that exceed the levels identified in 10 CFR 70.61 (CFR, 2003c).

For this license application, two ISA Teams were formed. This was necessary because the sensitive nature of some of the facility design information related to the enrichment process required the use of personnel with the appropriate national security clearances. This team performed the ISA on the Cascade System, Contingency Dump System, Centrifuge Test System and the Centrifuge Post Mortem System. This ISA Team is referred to as the Classified ISA Team. The Non-Classified Team, referred to in the remainder of this text as the ISA Team, performed the ISA on the remainder of the facility systems and structures. In addition, the (non-classified) ISA Team performed the External Events and Fire Hazard Assessment for the entire facility.

In preparing for the ISA, the Accident Analysis in the Safety Analysis Report (LES, 1993) for the Claiborne Enrichment Center was reviewed. In addition, experienced personnel with familiarity with the gas centrifuge enrichment technology safety analysis where used on the ISA Team. This provides a good peer check of the final ISA results.

A procedure was developed to guide the conduct of the ISA. This procedure was used by both teams. In addition, there were common participants on both teams to further integrate the approaches employed by both teams. These steps were taken to ensure the consistency of the results of the two teams. A non-classified summary of the results of the Classified ISA has been prepared and incorporated into the ISA Summary.

3.1.1.1 Hazard Identification

The hazard and operability (HAZOP) analysis method was used for identifying the hazards for the Uranium Hexafluoride (UF_6) process systems and Cylinder Receipt and Dispatch Building (CRDB) systems. This method is consistent with the guidance provided in NUREG-1513 and NUREG-1520. The hazards identification process results in identification of physical, radiological or chemical characteristics that have the potential for causing harm to site workers, the public, or to the environment. Hazards are identified through a systematic review process that entails the use of system descriptions, piping and instrumentation diagrams, process flow diagrams, plot plans, topographic maps, utility system drawings, and specifications of major process equipment. In addition, criticality hazards identification were performed for the areas of the facility where fissile material is expected to be present. The criticality safety analyses contain information about the location and geometry of the fissile material and other materials in the process, for both normal and credible abnormal conditions. The ISA input information is included in the ISA documentation and is available to be verified as part of an on-site review.

The hazard identification process documents materials that are:

- Radioactive
- Fissile
- Flammable
- Explosive
- Toxic
- Reactive.

The hazard identification also identifies potentially hazardous process conditions. Most hazards were assessed individually for the potential impact on the discrete components of the process systems. However, for hazards from fires (external to the process system) and external events (seismic, severe weather, etc.), the hazards were assessed on a facility wide basis.

For the purpose of evaluating the impacts of fire hazards, the ISA team considered the following:

- Postulated the development of a fire occurring in in-situ combustibles from an unidentified ignition source (e.g., electrical shorting, or other source)
- Postulated the development of a fire occurring in transient combustibles from an unidentified ignition source (e.g., electrical shorting, or other source)
- Evaluated the uranic content in the space and its configuration (e.g., UF_6 solid/gas in cylinders, UF_6 gas in piping, UF_6 and/or byproducts bound on chemical traps, Uranyl Fluoride (UO_2F_2) particulate on solid waste or in solution). The appropriate configuration was considered relative to the likelihood of the target releasing its uranic content as a result of a fire in the area.

In order to assess the potential severity of a given fire and the resulting failures to critical systems, the facility Fire Hazard Analysis was consulted. However, since the design supporting the license submittal for this facility is not yet at the detailed design stage, detailed in-situ combustible loading and in-situ combustible configuration information is not yet available. Therefore, in order to place reasonable and conservative bounds on the fire scenarios analyzed, the ISA Team estimated in situ combustible loadings based on information of the in situ combustible loading from Urenco's Almelo SP-5 plant (on which the National Enrichment Facility (NEF) design is based). This information from SP-5 indicates that in situ combustible loads are expected to be very low.

The Fire Safety Management Program will limit the allowable quantity of transient combustibles in critical plant areas (i.e., uranium areas). Nevertheless, the ISA Team still assumed the presence of moderate quantities of ordinary (Class A) combustibles (e.g., trash, packing materials, maintenance items or packaging, etc.) in excess of anticipated procedural limits. This was not considered a failure of the associated administrative IROFS feature for controlling/ minimizing transient combustible loading in all radiation/uranium areas. Failure of the IROFS is connoted as the presence of extreme or severe quantities of transients (e.g., large piles of combustible solids, bulk quantities of flammable/combustible liquids or gases, etc.). The Urenco ISA Team representatives all indicated that these types of transient combustible conditions do not occur in the European plants. Accordingly, and given the orientation and training that facility employees will receive indicating that these types of fire hazards are unacceptable, the administrative IROFS preventing severe accumulations has been assigned a high degree of reliability. Refer to Section 3.8.3 for additional discussion.

Fires that involve additional in-situ or transient combustibles from outside each respective fire area could result in exposure of additional uranic content being released in a fire beyond the quantities assumed above. For this reason, fire barriers are needed to ensure that fires cannot propagate from non-uranium containing areas into uranium (U) areas or from one U area to another U area (unless the uranium content in the space is insignificant, i.e., would be a low consequence event). Fire barriers shall be designed with adequate safety margin such that the total combustible loading (in-situ and transient) allowed to expose the barrier will not exceed 80% of the hourly fire resistance rating of the barrier.

For external events, the impacts were evaluated for the following hazards:

External events were considered at the site and facility level versus at individual system nodes. Specific external event HAZOP guidewords were developed for use during the external event portion of the ISA. The external event ISA considered both natural phenomena and man-made hazards. During the external event ISA team meeting, each area of the plant was discussed as to whether or not it could be adversely affected by the specific external event under consideration. If so, specific consequences were then discussed. If the consequences were known or assumed to be high, then a specific design basis with a likelihood of highly unlikely would be selected.

Given that external events were considered at the facility level, the ISA for external events was performed after the ISA team meetings for all plant systems were completed. This provided the best opportunity to perform the ISA at the site or facility level. Each external event was assessed for both the uncontrolled case and then for the controlled case. The controlled cases could be a specific design basis for that external event, IROFS or a combination of both. An Accident Sequence and Risk matrix was prepared for each external event.

External events evaluated included:

- Seismic
- Tornado, Tornado Missile and High Wind
- Snow and Ice
- Flooding
- Local Precipitation
- Other (Transportation and Nearby Facility Accidents)
- Aircraft
- Pipelines
- Highway
- Other Nearby Facilities
- Railroad
- Internal Flooding from On-Site Above Ground Liquid Storage Tanks.

The ISA is intended to give assurance that the potential failures, hazards, accident sequences, scenarios, and IROFS have been investigated in an integrated fashion, so as to adequately consider common mode and common cause situations. Included in this integrated review is the identification of IROFS function that may be simultaneously beneficial and harmful with respect to different hazards, and interactions that might not have been considered in the previously completed sub-analyses. This review is intended to ensure that the designation of one IROFS does not negate the preventive or mitigation function of another IROFS. An integration checklist is used by the ISA Team as a guide to facilitate the integrated review process.

Some items that warrant special consideration during the integration process are:

- Common mode failures and common cause situations.
- Support system failures such as loss of electrical power or city water. Such failures can have a simultaneous effect on multiple systems.

- Divergent impacts of IROFS. Assurance must be provided that the negative impacts of an IROFS, if any, do not outweigh the positive impacts; i.e., to ensure that the application of an IROFS for one safety function does not degrade the defense-in-depth of an unrelated safety function.
- Other safety and mitigating factors that do not achieve the status of IROFS that could impact system performance.
- Identification of scenarios, events, or event sequences with multiple impacts, i.e. impacts on chemical safety, fire safety, criticality safety, and/or radiation safety. For example, a flood might cause both a loss of containment and moderation impacts.
- Potential interactions between processes, systems, areas, and buildings; any interdependence of systems, or potential transfer of energy or materials.
- Major hazards or events, which tend to be common cause situations leading to interactions between processes, systems, buildings, etc.

3.1.1.2 HAZOP Hazard Analysis Method

As noted above, the HAZOP method was used to identify the process hazards. The HAZOP process hazard analysis (PHA) method is consistent with the guidance provided in NUREG-1513. Implementation of the HAZOP method was accomplished by either validating the Urenco HAZOPs for the NEF design or performing a new HAZOP for systems where there were no existing HAZOPs. In general, new HAZOPs were performed for the CRDB systems. In cases for which there was an existing HAZOP, the ISA Team, through the validation process, developed a new HAZOP.

For the UF_6 process systems, this portion of the ISA was a validation of the HAZOPs provided by Urenco. The validation process involved workshop meetings with the ISA Team. In the workshop meeting, the ISA Team challenged the results of the Urenco HAZOPs. As necessary the HAZOPs were revised/updated to be consistent with the requirements identified in 10 CFR 70 (CFR, 2003b) and as further described in NUREG-1513 and NUREG-1520.

To validate the Urenco HAZOPs, the ISA Team followed the HAZOP process as discussed in Guidelines for Hazard Evaluation Procedures (AICHE, 1992). Additional steps performed in this validation that are not identified in the above reference include:

- The ISA Team created a list of deviations for the UF_6 process, other processes in which the deviation could potentially impact the UF_6 process, and for external events (i.e., deviations from normal weather or external activities).
- For each potential hazard, the ISA Team considered the causes, including potential interactions among materials. Then, for each cause, the ISA Team considered the consequences and consequence severity category for the consequences of interest (Criticality Events, Chemical Releases, Radiation Exposure, Environment impacts). A statement of "No Safety Issue" was noted in the system HAZOP table for consequences of no interest such as maintenance problems or industrial personnel accidents.
- In additional to identification of safeguards, the ISA Team also considered any existing design features that could mitigate/reduce the consequences.
- For each external event hazard, the ISA Team determined if the external hazard is credible (i.e., external event initiating frequency >10-6 per year).

- The Urenco HAZOP was modified to reflect the ISA Team's input in the areas of hazards, causes, consequences, safeguards and mitigating features.

The same process as above was followed for the CRDB systems, except that instead of using the validation process, the ISA Team developed a completely new HAZOP. This HAZOP was then used as the hazard identification input into the remainder of the process.

The results of the ISA Team workshops are summarized in the ISA HAZOP Table, which forms the basis of the hazards portion of the Hazard and Risk Determination Analysis. The HAZOP tables are contained in the ISA documentation. The format for this table, which has spaces for describing the node under consideration and the date of the workshop, is provided in Table 3.1-2, ISA HAZOP Table Sample Format. This table is divided into 7 columns:

GUIDEWORD	Identifies the Guideword under consideration.
HAZARD	Identifies any issues that are raised.
CAUSES	Lists any and all causes of the hazard noted.
CONSEQUENCES	Identifies the potential and worst case consequence and consequences severity category if the hazard goes uncontrolled.
SAFEGUARDS	Identifies the engineered and/or administrative protection designed to prevent the hazard from occurring.
MITIGATION	Identifies any protection, engineered or otherwise, that can mitigate/reduce the consequences.
COMMENTS	Notes any comments and any actions requiring resolution.

This approach was used for all of the process system hazard identifications. The "Fire" and "External Events" guidewords were handled as a facility-wide assessment and were not explicitly covered in each system hazard evaluation.

The results of the HAZOP are used directly as input to the risk matrix development.

3.1.1.3 What-If/Checklist Hazard Analysis Method

The guidance from NUREG-1513 is followed for the What-IF/Checklist hazard analysis method selection. The What-IF/Checklist Analysis technique is a combination of two hazard evaluation methods: What-If Analysis and Checklist Analysis. The method is performed by a ISA Team with personnel experienced with the subject process. The ISA Team uses the What-If Analysis technique to brainstorm various types of precess accidents that can occur. Then the ISA Team uses one or more checklist to help fill in any gaps that may have been missed. Rather than focusing on a specific list of design or operating features, checklists used in a What-If/Checklist Analysis are more general and focus on sources of hazards and accidents.

A What-If/Checklist Analysis consists of the following steps: (1) preparing for the review, (2) developing a list of What-If questions and issues, (3) using a checklist to cover any gaps, (4) evaluating each questions and issue, and (5) documenting the results.

For each What-If question, the ISA Team determines the likelihood, consequences, safeguards, and acceptability of risk. The ISA Team meetings results are summarized in the What-If/Checklist, which forms the Hazard and Risk Determination Analysis basis.

3.1.1.4 Failure Modes and Effects Analysis (FMEA) Hazard Analysis Method

The guidance from NUREG-1513 recommends the FMEA hazard analysis method use. The FMEA is a systematic method for examining the effects of component failures on system performance. To perform the FMEA, an individual analyst lists all the components in the system under review, as well as all the failure modes for these components. The ISA Team made of analysts familiar with the system then identifies the hazards associated with each component failure and suggests corrective actions when appropriate.

The FMEA technique:

- Defines physical system bounds
- Determines the effect of each component failure mode
- Identifies safeguards to protect against the causes and/or consequences of each component failure mode
- Lists system components and postulates failure modes for each component and each physical bound
- Suggests actions for improving the system if the risk is deemed unacceptable

3.1.1.5 Risk Matrix Development

3.1.1.5.1 Consequence Analysis Method

10 CFR 70.61 (CFR, 2003c) specifies two categories for accident sequence consequences: "high consequences" and "intermediate consequences." Implicitly there is a third category for accidents that produce consequences less than "intermediate." These are referred to as "low consequence" accident sequences. The primary purpose of PHA is to identify all uncontrolled and unmitigated accident sequences. These accident sequences are then categorized into one of the three consequence categories (high, intermediate, low) based on their forecast radiological, chemical, and/or environmental impacts.

For evaluating the magnitude of the accident consequences, calculations were performed using the methodology described in the ISA documentation. Because the consequences of concern are the chemotoxic exposure to hydrogen fluoride (HF) and UO_2F_2, the dispersion methodology discussed in Section 6.3.2 was used. The dose consequences for all of the accident sequences were evaluated and compared to the criteria for "high" and "intermediate" consequences. The inventory of uranic material for each accident considered was dependent on the specific accident sequence. For criticality accidents, the consequences were conservatively assumed to be high for both the public and workers.

Table 3.1-3, Consequence Severity Categories Based on 10 CFR 70.61, presents the radiological and chemical consequence severity limits of 10 CFR 70.61 (CFR, 2003c) for each of the three accident consequence categories. Table 3.1-4, Chemical Dose Information, provides information on the chemical dose limits specific to the NEF.

3.1.1.5.2 Likelihood Evaluation Method

10 CFR 70.61 (CFR, 2003c) also specifies the permissible likelihood of occurrence of accident sequences of different consequences. "High consequence" accident sequences must be "highly unlikely" and "intermediate consequence" accident sequences must be "unlikely." Implicitly, accidents in the "low consequence" category can have a likelihood of occurrence less than "unlikely" or simply "not unlikely." Table 3.1-5, Likelihood Categories Based on 10 CFR 70.61, shows the likelihood of occurrence limits of 10 CFR 70.61 (CFR, 2003c) for each of the three likelihood categories.

The definitions of "not unlikely" and "unlikely" are taken from NUREG-1520. The definition of "highly unlikely" is taken from NUREG-1520. Additionally, a qualitative determination of "highly unlikely" can apply to passive design component features (e.g., tanks, piping, cylinders, etc.) of the facility that do not rely on human interface to perform the criticality safety function (i.e., termed "safe-by-design"). Safe-by-design components are those components that by their physical size or arrangement have been shown to have a $k_{eff} < 0.95$. The definition of safe-by-design components encompasses two different categories of components. The first category includes those components that are safe-by-volume, safe-by-diameter or safe-by-slab thickness. A set of generic conservative criticality calculations has determined the maximum volume, diameter, or slab thickness (i.e., safe value) that would result in a $k_{eff} < 0.95$. A component in this category has a volume, diameter or slab thickness that is less than the associated safe value resulting from the generic conservative criticality calculations and therefore the k_{eff} associated with this component is < 0.95. The components in the second category require a more detailed criticality analysis (i.e., a criticality analysis of the physical arrangement of the component's design configuration) to show that k_{eff} is < 0.95. In the second category of components, the design configuration is not bounded by the results of the generic conservative criticality calculations for maximum volume, diameter, or slab thickness that would result in a $k_{eff} < 0.95$. Examples of components in this second category are the product pumps that have volumes greater than the safe-by-volume value, but are shown by specific criticality analysis to have a $k_{eff} < 0.95$.

For failure of passive safe-by-design components to be considered "highly unlikely," these components must also meet the criterion that the only potential means to effect a change that might result in a failure to function, would be to implement a design change (i.e., geometry deformation as a result of a credible process deviation or event does not adversely impact the performance of the safety function). The evaluation of the potential to adversely impact the safety function of these passive design features includes consideration of potential mechanisms to cause bulging, corrosion, and breach of confinement/leakage and subsequent accumulation of material. The evaluation further includes consideration of adequate controls to ensure that the double contingency principle is met. For each of these passive design components, it must be concluded, that there is no credible means to effect a geometry change that might result in a failure of the safety function and that significant margin exists. For components that are safe-by-volume, safe-by-diameter, or safe-by-slab thickness (i.e., first category of safe-by-design components), significant margin is defined as a margin of at least 10%, during both normal and upset conditions, between the actual design parameter value of the component and the value of the corresponding critical design attribute. For components that require a more detailed criticality analysis (i.e., second category of safe-by-design components), significant margin is defined as $k_{eff} < 0.95$, where $k_{eff} = k_{calc} + 3\sigma_{calc}$. This margin is considered acceptable since the calculation of k_{eff} also conservatively assumes the components are full of uranic breakdown material at maximum credible enrichment for that system, the worst credible moderation conditions exist, and the worst credible reflection conditions exist.

The demonstration of significant margin to meet "highly unlikely" is provided, for each of the components listed in Tables 3.7-6 through 3.7-21, in the following classified documents.

- ETC4009554, Criticality Assessment of Passive Safe-by-Design Components, Decontamination Workshop
- ETC4009555, Criticality Assessment of Passive Safe-by-Design Components, Mass Spectrometry Laboratory
- ETC4009556, Criticality Assessment of Passive Safe-by-Design Components, Chemical Laboratory System
- ETC4009557, Criticality Assessment of Passive Safe-by-Design Components, Fomblin Oil Recovery System
- ETC4009558, Criticality Assessment of Passive Safe-by-Design Components, Solid Waste Collection System
- ETC4009559, Criticality Assessment of Passive Safe-by-Design Components, Product Blending System
- ETC4009561, Criticality Assessment of Passive Safe-by-Design Components, Cascade System
- ETC4009565, Criticality Assessment of Passive Safe-by-Design Components, Centrifuge Test System
- ETC4009566, Criticality Assessment of Passive Safe-by-Design Components, Centrifuge Post Mortem Facility
- ETC4009567, Criticality Assessment of Passive Safe-by-Design Components, Contingency Dump System
- ETC4009609, Criticality Assessment of Passive Safe-by-Design Components, Tails System
- ETC4009614, Criticality Assessment of Passive Safe-by-Design Components, Product System
- ETC4009677, Criticality Assessment of Passive Safe-by-Design Components, Liquid Effluent Collection and Treatment System
- ETC4009679, Criticality Assessment of Passive Safe-by-Design Components, Ventilated Room System
- ETC4009730, Criticality Assessment of Passive Safe-by-Design Components, Liquid Sampling System

These classified documents are incorporated by reference into this ISA Summary.

In addition, the configuration management system required by 10 CFR 70.72 (implemented by the NEF Configuration Management Program) ensures the maintenance of the safety function of these features and assures compliance with the double contingency principle, as well as the defense-in-depth criterion of 10 CFR 70.64(b).

The definition of "not credible" is also taken from NUREG-1520. If an event is not credible, IROFS are not required to prevent or mitigate the event. The fact that an event is not "credible" must not depend on any facility feature that could credibly fail to function. One cannot claim that a process does not need IROFS because it is "not credible" due to characteristics provided by IROFS. The implication of "credible" in 10 CFR 70.61 (CFR, 2003c) is that events that are not "credible" may be neglected.

Any one of the following independent acceptable sets of qualities could define an event as not credible:

a. An external event for which the frequency of occurrence can conservatively be estimated as less than once in a million years
b. A process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive (In determining that there is no reason for such actions, a wide range of possible motives, short of intent to cause harm, must be considered. Necessarily, no such sequence of events can ever have actually happened in any fuel cycle facility.)
c. Process deviations for which there is a convincing argument, given physical laws that they are not possible, or are unquestionably extremely unlikely.

3.1.1.5.3 Risk Matrix

The three categories of consequence and likelihood can be displayed as a 3 x 3 risk index matrix. By assigning a number to each category of consequence and likelihood, a qualitative risk index can be calculated for each combination of consequence and likelihood. The risk index equals the product of the integers assigned to the respective consequence and likelihood categories. The risk index matrix, along with computed risk index values, is illustrated in Table 3.1-6, Risk Matrix with Risk Index Values. The shaded blocks identify accidents of which the consequences and likelihoods yield an unacceptable risk index and for which IROFS must be applied.

The risk indices can initially be used to examine whether the consequences of an uncontrolled and unmitigated accident sequence (i.e., without any IROFS) could exceed the performance requirements of 10 CFR 70.61 (CFR, 2003c). If the performance requirements could be exceeded, IROFS are designated to prevent the accident or to mitigate its consequences to an acceptable level. A risk index value less than or equal to four means the accident sequence is acceptably protected and/or mitigated. If the risk index of an uncontrolled and unmitigated accident sequence exceeds four, the likelihood of the accident must be reduced through designation of IROFS. In this risk index method, the likelihood index for the uncontrolled and unmitigated accident sequence is adjusted by adding a score corresponding to the type and number of IROFS that have been designated.

3.1.1.6 Risk Index Evaluation Summary

The results of the ISA are summarized in tabular form (see Section 3.7, General Types of Accident Sequences). This table includes the accident sequences identified for this facility. The accident sequences were not grouped as a single accident type but instead were listed individually in the table. The Table has columns for the initiating event and for IROFS. IROFS may be mitigative or preventive. Mitigative IROFS are measures that reduce the consequences of an accident. The phrase "uncontrolled and/or unmitigated consequences" describes the results when the system of existing preventive IROFS fails and existing mitigation also fails. Mitigated consequences result when the preventive IROFS fail, but mitigative measures succeed. Index numbers are assigned to initiating events, IROFS failure events, and mitigation failure events, based on the reliability characteristics of these items.

With redundant IROFS and in certain other cases, there are sequences in which an initiating event places the system in a vulnerable state. While the system is in this vulnerable state, an IROFS must fail for the accident to result. Thus, the frequency of the accident depends on the frequency of the first event, the duration of vulnerability, and the frequency of the second IROFS failure. For this reason, the duration of the vulnerable state is considered, and a duration index is assigned. The values of all index numbers for a sequence, depending on the number of events involved, are added to obtain a total likelihood index, T. Accident sequences are then assigned to one of the three likelihood categories of the risk matrix, depending on the value of this index in accordance with Table 3.1-8, Determination of Likelihood Category.

The values of index numbers in accident sequences are assigned considering the criteria in Tables 3.1-9 through 3.1-11. Each table applies to a different type of event. Table 3.1-9, Failure Frequency Index Numbers, applies to events that have frequencies of occurrence, such as initiating events and certain IROFS failures. In addition to further support the failure frequency index numbers used in the ISA (i.e., when ISA Summary Tables 3.7-2 and 3.7-4 state "This failure frequency index was selected based on evidence from history of similarly designed Urenco European plant..."), operating data from similar systems, components, and safety functions at the Urenco Almelo SP5 facility, which is similar to the NEF design, is reviewed. This review is conducted using searches of computer-based databases at the Urenco Almelo facility. A list of ISA Summary initiating events caused by component failures or human events is developed. Using this list of initiating events, keyword searches of computer based databases for plant control systems, operational logs, and maintenance records are performed. The resulting information relevant to the Almelo SP5 facility is extracted for further review, evaluation, and comparison to the failure frequency index number(s) used in the applicable ISA Summary accident sequences. When failure probabilities are required for an event, Table 3.1-10, Failure Probability Index Numbers, provides the index values. Table 3.1-11, Failure Duration Index Numbers, provides index numbers for durations of failure. These are used in certain accident sequences where two IROFS must simultaneously be in a failed state. In this case, one of the two controlled parameters will fail first. It is then necessary to consider the duration that the system remains vulnerable to failure of the second. This period of vulnerability can be terminated in several ways. The first failure may be "fail-safe" or be continuously monitored, thus alerting the operator when it fails so that the system may be quickly placed in a safe state. Or the IROFS may be subject to periodic surveillance tests for hidden failures. When hidden failures are possible, these surveillance intervals limit the duration that the system is in a vulnerable state. The reverse sequences, where the second IROFS fails first, should be considered as a separate accident sequence. This is necessary because the failure frequency and the duration of outage of the first and the second IROFS may differ. The values of these duration indices are not merely judgmental. They are directly related to the time intervals used for surveillance and the time needed to render the system safe.

The duration of failure is accounted for in establishing the overall likelihood that an accident sequence will continue to the defined consequence. Thus, the time to discover and repair the failure is accounted for in establishing the risk of the postulated accident.

The total likelihood index is the sum of the indices for all the events in the sequence, including those for duration. Consequences are assigned to one of the three consequence categories of the risk matrix, based on calculations or estimates of the actual consequences of the accident sequence. The consequence categories are based on the levels identified in 10 CFR 70.61 (CFR, 2003c). Multiple types of consequences can result from the same event. The consequence category is chosen for the most severe consequence.

In summarizing the ISA results, Table 3.7-1, Accident Sequence and Risk Index, provides two risk indices for each accident sequence to permit evaluation of the risk significance of the IROFS involved. To measure whether an IROFS has high risk significance, the table provides an "uncontrolled risk index," determined by modeling the sequence with all IROFS as failed (i.e., not contributing to a lower likelihood). In addition, a "controlled risk index" is also calculated, taking credit for the low likelihood and duration of IROFS failures. When an accident sequence has an uncontrolled risk index exceeding four but a controlled risk index of less than four, the IROFS involved have a high risk significance because they are relied on to achieve acceptable safety performance. Thus, use of these indices permits evaluation of the possible benefit of improving IROFS and also whether a relaxation may be acceptable.

3.1.2 ISA Team

There were two ISA Teams that were employed in the initial ISA. The first team worked on the non-classified portions of the facility and is referred to in the text as the ISA Team. The second team, referred to as the Classified ISA Team, performed the ISA on the classified elements of the facility. Both teams were selected with credentials consistent with the requirements in 10 CFR 70.65 (CFR, 2003a) and the guidance provided in NUREG-1520. To facilitate consistency of results, common membership was dictated as demonstrated below (i.e., some members of the Non-Classified Team participated on the Classified Team. One of the members of the Classified Team participated in the ISA Team Leader Training, which was conducted prior to initiating the ISA. In addition, the Classified ISA Team Leader observed some of the non-classified ISA Team meetings.

The ISA was performed by a team with expertise in engineering, safety analysis and enrichment process operations. The team included personnel with experience and knowledge specific to each process or system being evaluated. The team was comprised of individuals who have experience, individually or collectively, in:

- Nuclear criticality safety
- Radiological safety
- Fire safety
- Chemical process safety
- Operations and maintenance
- ISA methods.

The ISA team leader was trained and knowledgeable in the ISA method(s) chosen for the hazard and accidents evaluations. Collectively, the team had an understanding of all process operations and hazards under evaluation.

The ISA Manager was responsible for the overall direction of the ISA. The process expertise was provided by the Urenco personnel on the team. In addition, the Team Leader has an adequate understanding of the process operations and hazards evaluated in the ISA, but is not the responsible cognizant engineer or enrichment process expert.

A description of the ISA Team, their areas of expertise, qualifications and experience is provided below.

ISA Team Member	Experience and Qualifications
Michael Kennedy, ISA Manager and Team Leader	Over 29 years experience in nuclear safety analyses and risk assessment. Advanced degrees in Nuclear Engineering. Completed ISA Team Leader training course.
Richard Turcotte, Team Leader	Over 25 years experience providing engineering and risk assessment support for nuclear plants. Significant experience in probabilistic risk assessment. Degreed Mechanical Engineer. Completed ISA Team Leader training course.

ISA Team Member	Experience and Qualifications
Melvin Gmyrek, Team Leader	Over 30 years experience in nuclear facility operations. Has held a number of reactor operator licenses and held positions as Senior Reactor Operator, shift supervisor and operations manager. Completed ISA Team Leader training course.
David Pepe, Scribe	Over 26 years experience in providing engineering and risk assessment support on nuclear facilities. Significant experience in probabilistic risk assessment. Degreed Nuclear Engineer. Completed ISA Team Leader training course.
Scott Tyler, Chemical/Fire Safety	Over 17 years experience in fire and chemical safety on nuclear and non-nuclear facilities. Experienced in process hazard and consequence analysis. Degreed engineer in Fire Protection and Safety Engineering Technology and a registered Professional Fire Protection Engineer.
Richard Dible, Fire Safety	Over 19 years experience in fire protection and analysis. Degreed engineer in Fire Protection and Safety Engineering.
Douglas Setzer, Chemical/Fire Safety	Over 16 years experience in design and analysis in chemical and fire safety. Experienced in process hazard and consequence analysis. Degreed engineer in Mechanical and Chemical engineering. Registered Professional Fire Protection Engineer.
Kevin Morrissey, Criticality Safety	Over 24 years of nuclear industry experience, including particle transport methods, nuclear criticality, activation analysis and reactor physics.
Mark Strum, Radiological Safety	Over 30 years of nuclear utility experience performing radiological assessments supporting the design, licensing and operation of both PWR and BWR nuclear power plant facilities. Degreed nuclear engineer with an advanced degree in Radiological Sciences and Protection.
Chris Andrews, Process Expert	Over 30 years experience in the licensing, engineering and safety analysis of gas centrifuge enrichment technology. Senior Manager responsible for safety analysis and licensing for Urenco. Degree in Physics. Professional Engineer. Completed ISA Team Leader training course.
Allan Brown, Process Expert	Over 26 years experience in the design, operations, start-up, decommissioning of gas centrifuge enrichment facilities. Design Manager with responsibility for the NEF for Urenco. Degree in Physics.

ISA Team Member	Experience and Qualifications
Jan Kleissen, Operations Expert	Over 30 years experience in the operation and start-up of gas centrifuge enrichment plants. Production Manager at the Almelo SP-5 plant. The NEF is based on the SP-5 design. Degreed engineer.
Edwin Mulder, Operations Expert	Over four years experience in operations of gas centrifuge enrichment plant.
Herald Voschezang, Operations Expert	Over 19 years of experience with Urenco, predominantly in operations of gas centrifuge enrichment plants. Commissioning Manager of the Almelo SP-5 plant. The NEF is based on the SP-5 design. Degreed engineer.
Randy Campbell, Facility Engineering	Over 25 years experience in engineering, design and construction in the power (nuclear and fossil), chemicals, automotive and other various industries and 12 years nuclear experience. Degreed Mechanical Engineer.

Classified ISA Team Member	Experience and Qualifications
Andrew Pilkington, Team Leader/Risk Analysis	Over 14 years experience in nuclear and non-nuclear facility risk assessment. Significant experience in the risk assessment of gas centrifuge enrichment facilities. Knowledgeable in the HAZOP methodology. Degreed engineer.
Tony Duff, Scribe/Risk Analysis	Over 13 years experience in nuclear facility risk assessment. Most recent experience in gas centrifuge enrichment facility risk assessment. Degree in Applied Physics.
Chris Andrews, Process Safety	Over 30 years experience in the licensing, engineering and safety analysis of gas centrifuge enrichment technology. Senior Manager responsible for safety analysis and licensing for Urenco. Degree in Physics. Professional Engineer. Completed ISA Team Leader training course.
Edwin Mulder, Operations Expert	Over four years experience in operations of gas centrifuge enrichment plant.
Philip Hale, Lead Engineer	Over 21 years experience in mechanical and process design engineering on gas centrifuge enrichment facilities. Lead design engineer for the NEF. Advanced degree in Mechanical Engineering.

Classified ISA Team Member	Experience and Qualifications
Owen Parry, Criticality	Over 20 years experience in gas centrifuge technology. Most recent experience is in the criticality analysis related to gas centrifuge enrichment facilities. Degree in Chemistry and Doctoral degree in Physics.
Ian Forrest, Dump Systems	Over 27 years experience in design engineering. Presently package manager for work associated with development and qualification of Dump Systems, and providing related support for plant and projects. Degreed Mechanical Engineer.
Alan Coles, Fire Safety	Over 36 years experience in fire protection and fire safety.
Heather Tur, Test Facilities	Over 32 years experience in centrifuge research and development and centrifuge test facility operations.
Ian Crombie, Test Facilities	Over 20 years experience in design engineering related to gas centrifuge enrichment plant. Most recently involved in the NEF design.
Herald Voschezang, Operations Expert	Over 19 years of experience with Urenco, predominantly in operations of gas centrifuge enrichment plants. Commissioning Manager of the Almelo SP-5 plant. The NEF is based on the SP-5 design. Degreed engineer.
Stephen Thomas, Process Design Engineer	Over 25 years of experience. Approximately 10 years of centrifuge plant design experience. Design support for NEF design.

The management commitments related to the conduct and maintenance of the ISA are described in Section 3.1.8.2, Integrated Safety Analysis.

3.1.3 Selection of Quantitative Standards

Uranium hexafluoride (UF_6) is the only chemical of concern that will be used at the facility. For licensed material or hazardous chemicals produced from licensed materials, chemicals of concern are those that, in the event of release have the potential to exceed concentrations defined in 10 CFR Part 70 (CFR, 2003b). UF_6 represents a health hazard to facility workers and the public if released to atmosphere due to the radiological and toxicological properties of two byproducts – HF and uranyl fluoride (UO_2F_2) – which are generated when UF_6 is released and reacts with water vapor in the air.

Criteria for evaluating potential releases and characterizing their consequences as either "high" or "intermediate" for members of the public and facility workers are presented in Table 3.1-3, Consequence Severity Categories Based on 10 CFR 70.61 and Table 3.1-4, Chemical Dose Information.

3.1.4 Hazards Analyzed

The hazards of concern for this facility are all related to either a loss of confinement (of UF_6) or criticality. All of the consequences of concern are the result of initiating events due to hazards that would result in accidents of these types. The initiating events considered for this facility are the result of failures in process components, human error or misoperation including maintenance activities, fires (external to the process), and external events (e.g., severe weather, seismic, transportation and industrial hazards). These initiating events or potential causes could result in a loss of enrichment system containment or criticality. In general, the loss of confinement would initially result in an in-leakage of air because the systems are at sub-atmospheric pressure. Moisture in the air would react with the UF_6 forming UO_2F_2 and HF as by-products. The HF, which would be in a gaseous form, could be transported through the facility and ultimately beyond the site boundary. HF is a toxic chemical with the potential to cause harm to the plant workers or the public.

A criticality event, if one should occur, is a potential source of damaging energy and would result in the release of prompt gamma rays and airborne fission products. The gamma rays and airborne fission products result in direct radiation and chemical/radiological inhalation dose exposure to plant workers and the public. Each portion of the plant, system, or component that may possibly contain enriched uranium is designed with criticality safety as an objective. Where there is a potential for significant in-process accumulations of enriched uranium, the plant design includes multiple features to minimize the possibilities for breakdown of criticality control features.

Nuclear criticality safety is evaluated for the design features of the plant system or component and for the operating practices that relate to maintaining criticality safety. The evaluation of individual systems or components and their interaction with other systems or components containing enriched uranium is performed to assure the criticality safety criteria are met. The nuclear criticality safety analyses provide a basis for the plant design and criticality hazards identifications performed as part of the ISA.

3.1.5 Criticality Monitoring and Alarms

The facility is provided with a Criticality Accident Alarm System (CAAS) as required by 10 CFR 70.24, Criticality accident requirements (CFR, 2003d). Areas where Special Nuclear Material (SNM) is handled, used, or stored in amounts at or above the 10 CFR 70.24 (CFR, 2003d) mass limits are provided with CAAS coverage.

The CAAS is designed, installed, and maintained in accordance with ANSI/ANS-8.3 Criticality Accident Alarm System as modified by Regulatory Guide 3.71, Nuclear Criticality Safety Standards Fuels and Material Facilities.

CAAS coverage consists of an overlapping detection layout, where all required covered areas are monitored by a minimum of a pair (2) of gamma detectors. Detectors trip based on both steady radiation rate and time integrated total radiation dose levels. The detectors have a stated trigger response of 1mGy/hr (0.1 rad/hr) as a gamma radiation rate meter detector. Based on this design and the guidance provided in Appendix B of ANSI/ANS-8.3, the radius of detection must be less than 106 m (348 ft). Because of building steel spacing and equipment arrangement as well as a desire to maintain a factor of two safety margin, a radius of detection of 40 m (131 ft) is used in the design. This ensures that the CAAS is capable of detecting a criticality that produces an absorbed dose in soft tissue of 0.2 Gy (20 rads) of combined neutron and gamma radiation at an unshielded distance of 2 m (6.6 ft) from the reacting material within one minute. The CAAS will be uniform throughout the facility for the type of radiation detected, the mode of detection, the alarm signal, and the system dependability. The CAAS, if tripped, will automatically initiate a clearly audible signal in areas that must be evacuated.

The CAAS is provided with back-up power and is designed to remain operational during credible events or conditions. Components are located or protected to minimize damage in case of credible events such as fire, explosion, corrosive atmosphere, and seismic shock (equivalent to the site-specific design-basis earthquake or the equivalent value specified by the building code).

Anytime CAAS coverage is lost and not restored within a specified number of hours (determined on a process-by-process basis), operations will be rendered safe (by shutdown and quarantine) as appropriate. Onsite guidance will be utilized based on process-specific considerations that consider applicable risk trade-off of the duration of reliance on compensatory measures versus the risk associated with process upset in shutdown. Follow the occurrence of a credible event or whenever the CAAS is not functional, compensatory measures such as evacuation, limiting access and restricting SNM movement, will be implemented until CAAS coverage is verified operational. Radiation surveys will be conducted prior to re-entry to confirm conditions in the area.

3.1.6 Fire Hazards Analysis

Fire Hazards Analyses (FHAs) are conducted for the processing buildings located within the site boundary. The FHA evaluates the facility design with respect to fire safety codes, and ensures that the facility is designed and operated such that there is acceptable risk for postulated fire accident scenarios.

The results of the FHA have been used to identify potential fire initiators and accident sequences leading to radiological consequences or toxic chemical consequences. The FHA is a fundamental input for evaluating fire hazards in the ISA.

3.1.7 Baseline Design Criteria

10 CFR 70.64 (CFR, 2003e) specifies baseline design criteria (BDC) that must be used for new facilities. The ISA accident sequences for the credible high and intermediate consequence events for the NEF have defined the design basis events. The IROFS for these events and safety parameter limits ensure that the associated BDC are satisfied. IROFS safety parameter limits are available in the ISA documentation. These BDC have been used as bases for the design of the NEF.

A. Quality Standards and Records.

Structures, systems, and components (SSCs) that are determined to have safety significance are designed, fabricated, erected, and tested in accordance with the quality assurance criteria set forth in Appendix B to 10 CFR Part 50 (CFR, 2003f). Appropriate records of the design, fabrication, erection, procurement and testing of SSCs which are determined to have safety significance are maintained throughout the life of the facility. A safety function is a function performed by a SSC that prevents a release of UF_6 to the environment that could result in a dose to a member of the public of at least the limits provided in Section 3.1.3, Selection of Quantitative Standards. An SSC that performs a safety function is designated as an engineered IROFS. An activity by personnel that performs a safety function is designated as an administrative IROFS. Management Measures applicable to IROFS are discussed in Section 3.1.8.3, Management Measures.

B. Natural Phenomena Hazards.

Structures, systems, and components that are determined to have safety significance (IROFS) are designed to withstand the effects of, and be compatible with, the environmental conditions associated with operation, maintenance, shutdown, testing, and accidents for which the IROFS are required to function.

Natural phenomena hazards are identified in Section 3.2, Site Description.

C. Fire Protection.

Structures, systems, and components that are determined to have safety significance (IROFS) are designed and located so that they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Non-combustible and heat resistant materials are used wherever practical throughout the facility, particularly in locations vital to the control of hazardous materials and to the maintenance of safety control functions. Cables for unlimited use including open cable trays are flame retardant and tested (FT4 or IEEE 1202 type test) in accordance with the guidance of ANSI/IEEE 383, IEEE 1202, UL 1277, UL 1685, UL 83 (FT4), UL 1581 (FT4), CSA C22.2 (FT4), or ICEA T-30-520. Cable used inside panels, cabinets, and enclosed equipment are flame retardant and tested (FT1 oe VW-1 type test) in accordance with the guidance of UL 1581, UL 508A, UL 1063, or UL 83. Fire detection, alarm, and suppression systems are designed and provided with sufficient capacity and capability to minimize the adverse effects of fires and explosion on IROFS. The design includes provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

D. Environmental and Dynamic Effects.

Structures, systems, and components that are determined to have safety significance (IROFS) are protected against dynamic effects, including effects of missiles and discharging fluids, that may result from natural phenomena, accidents at nearby industrial, military, or transportation facilities, equipment failure, and other similar events and conditions both inside and outside the facility.

E. Chemical Protection.

The design provides adequate protection against chemical risks produced from licensed material, facility conditions which affect the safety of licensed material, and hazardous chemicals produced from licensed material.

F. Emergency Capability.

Structures, systems, and components that are required to support the Emergency Plan are designed for emergencies. The design provides accessibility to the equipment of onsite and available offsite emergency facilities and services such as hospitals, fire and police departments, ambulance service, and other emergency agencies.

G. Utility Services.

Onsite utility service systems required to support IROFS shall be provided. Each utility service system required to support IROFS shall provide for the meeting of safety demands under normal and abnormal conditions.

Utility systems are described in Section 3.5, Utility and Support Systems.

H. Inspection, Testing, and Maintenance.

Structures, systems and components that are determined to have safety significance (IROFS) are designed to permit inspection, maintenance, and testing.

I. Criticality Control.

Safety Margins

The design of process and storage systems shall include demonstrable margins of safety for the nuclear criticality parameters that are commensurate with the uncertainties in the process and storage conditions, in the data and methods used in calculations, and in the nature of the immediate environment under accident conditions. All process and storage systems should be designed and maintained with sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

Methods of Control

The major controlling parameters used in the facility are enrichment control, geometry control, moderation control and/or limitations on the mass as a function of enrichment.

Neutron Absorbers

Neutron Absorption is a factor in almost all of the materials at the NEF. The normal absorption of neutrons in standard materials used in the construction and processes at the NEF (uranium, fluorine, water, steel, etc.) is not specifically excluded as a criticality control parameter.

Models incorporate conservative values based on the process function of the neutron absorber. Depending on the function of the material, the bounding value may be validated at receipt, after installation, based on process knowledge during operation or by periodic surveillance. Neutron absorption by inherent structural or component materials, such as steel and aluminum, is not considered a fixed neutron absorber subject to ANSI/ANS-8.21 controls because removal potential is negligible and their continued presence is necessary to maintain plant operations.

Additional materials such as cadmium and boron for which the sole purpose would be to absorb neutrons are not incorporated in NEF processes. Solutions of absorbers are not used as a criticality control mechanism.

J. Instrumentation and Controls.

Instrumentation and control systems shall be provided to monitor variables and operating systems that are significant to safety over anticipated ranges for normal operation, for abnormal operation, for accident conditions, and for safe shutdown. These systems shall ensure adequate safety of process and utility service operations in connection with their safety function. The variables and systems that require constant surveillance and control include process systems having safety significance, the overall confinement system, confinement barriers and their associated systems, and other systems that affect the overall safety of the plant. Controls shall be provided to maintain these variables and systems within the prescribed operating ranges under all normal conditions. Instrumentation and control systems shall be designed to fail into a safe state or to assume a state demonstrated to be acceptable on some other basis if conditions such as disconnection, loss of energy or motive power, or adverse environments are experienced.

For hardware IROFS involving instrumentation that provides automatic prevention or mitigation of events, status and operation will be monitored by the plant control system (PCS) by means of an alarm. This alarm will be provided by an isolated, hardwired digital signal from the associated IROFS to the PCS programmable logic controller (PLC). This signal will only be directed from the associated IROFS to the PCS PLC. The required isolation is provided at the IROFS hardware interface in the process equipment for the connections to the PCS PLC. Consistent with IEEE-279, "Criteria for Protection Systems for Nuclear Power Generating Stations", the isolation devices will be classified as part of the IROFS boundary and will be designed such that no credible failure at the output of the isolation device shall prevent the associated IROFS from meeting its specified safety function.

K. Defense-in-Depth Practices.

The facility and system designs are based on defense-in-depth practices. The design incorporates a preference for engineered controls over administrative controls to increase overall system reliability. For criticality safety, the engineered controls preference is for use of passive engineered controls over active engineered controls. The design also incorporates features that enhance safety by reducing challenges to items relied on for safety. Facility and system IROFS are identified in Section 3.8, IROFS. The process systems are described in Section 3.4, Enrichment and Other Process Systems. The utility and support systems are described in Section 3.5, Utility and Support Systems. In addition to identifying the IROFS associated with each system, the system descriptions also identify the additional design and safety features (considerations) that provide defense-in-depth.

3.1.8 Safety Program Commitments

This section presents the commitments pertaining to the facility's safety program including the performance of an ISA. 10 CFR Part 70 (CFR, 2003b) contains a number of specific safety program requirements related to the integrated safety analysis (ISA). These include the primary requirements that an ISA be conducted, and that it evaluate and show that the facility complies with the performance requirements of 10 CFR 70.61 (CFR, 2003c).

The commitments for each of the three elements of the safety program defined in 10 CFR 70.62(a) (CFR, 2003g) are addressed below.

3.1.8.1 Process Safety Information

A. LES has compiled and maintains up-to-date documentation of process safety information. Written process-safety information is used in updating the ISA and in identifying and understanding the hazards associated with the processes. The compilation of written process-safety information includes information pertaining to:

1. The hazards of all materials used or produced in the process, which includes information on chemical and physical properties such as are included on Material Safety Data Sheets meeting the requirements of 29 CFR 1910.1200(g) (CFR, 2003h).
2. Technology of the process which includes block flow diagrams or simplified process flow diagrams, a brief outline of the process chemistry, safe upper and lower limits for controlled parameters (e.g., temperature, pressure, flow, and concentration), and evaluation of the health and safety consequences of process deviations.
3. Equipment used in the process including general information on topics such as the materials of construction, piping and instrumentation diagrams (P&IDs), ventilation, design codes and standards employed, material and energy balances, IROFS (e.g., interlocks, detection, or suppression systems), electrical classification, and relief system design and design basis.

The process-safety information described above is maintained up-to-date by the configuration management program.

B. LES has developed procedures and criteria for changing the ISA. This includes implementation of a facility change mechanism that meets the requirements of 10 CFR 70.72 (CFR, 2003i).

C. LES uses personnel with the appropriate experience and expertise in engineering and process operations to maintain the ISA. The ISA Team for the various processes consists of individuals who are knowledgeable in the ISA method(s) and the operation, hazards, and safety design criteria of the particular process.

The ISA Team for the initial ISA development is described in Section 3.1.2, ISA Team.

3.1.8.2 Integrated Safety Analysis

A. LES has conducted an ISA for each process, such that it identifies (i) radiological hazards, (ii) chemical hazards that could increase radiological risk, (iii) facility hazards that could increase radiological risk, (iv) potential accident sequences, (v) consequences and likelihood of each accident sequence and (vi) IROFS including the assumptions and conditions under which they support compliance with the performance requirements of 10 CFR 70.61 (CFR, 2003c).

The results of the ISA are presented in Section 3.6, Process Hazards; Section 3.7, General Types of Accident Sequences, and Section 3.8, IROFS.

B. LES has implemented programs to maintain the ISA and supporting documentation so that it is accurate and up-to-date. Changes to the ISA Summary are submitted to the NRC, in accordance with 10 CFR 70.72(d)(1) and (3) (CFR, 2003i). The ISA update process accounts for any changes made to the facility or its processes. This update will also verify that initiating event frequencies and IROFS reliability values assumed in the ISA remain valid. Any changes required to the ISA as a result of the update process will be included in a revision to the ISA. Evaluation of any facility changes or changes in the process safety information that may alter the parameters of an accident sequence is by the ISA method(s) as described in the ISA Summary Document. For any revisions to the ISA, personnel having qualifications similar to those of ISA team members who conducted the original ISA are used.

C. Personnel used to update and maintain the ISA and ISA Summary are trained in the ISA method(s) and are suitably qualified.

D. Proposed changes to the facility or its operations are evaluated by the ISA method(s) described in Section 3.1, General ISA Information. New or additional IROFS and appropriate management measures are designated as required. The adequacy of existing IROFS and associated management measures are promptly evaluated to determine if they are impacted by changes to the facility and/or its processes. If a proposed change results in a new type of accident sequence or increases the consequences or likelihood of a previously analyzed accident sequence within the context of 10 CFR 70.61 (CFR, 2003c), the adequacy of existing IROFS and associated management measures are promptly evaluated and the necessary changes are made, if required.

E. Unacceptable performance deficiencies associated with IROFS are addressed that are identified through updates to the ISA.

F. Written procedures are maintained on site.

G. All IROFS are maintained so that they are available and reliable when needed.

3.1.8.3 Management Measures

Management measures are functions applied to IROFS, and any items that may affect the function of IROFS. IROFS management measures ensure compliance with the performance requirements assumed in the ISA documentation. The measures are applied to particular structures, systems, equipment, components, and activities of personnel, and may be graded commensurate with the reduction of the risk attributable to that IROFS. The IROFS management measures shall ensure that these structures, systems, equipment, components, and activities of personnel within the identified IROFS boundary are designed, implemented, and maintained, as necessary, to ensure they are available and reliable to perform their function when needed, to comply with the performance requirements assumed in the ISA documentation.

The following types of management measures are required by the 10 CFR 70.4 definition of management measures. The description for each management measure reflects the general requirements applicable to each IROFS. Any management measure that deviates from the general requirements described in this section, which are consistent with the performance requirements assumed in the ISA documentation, are discussed in Section 3.8.3, Basis for Enhanced or High Availability Failure Probability Index Number. A cross reference from the associated IROFS in Table 3.8-1 to the applicable subsection is provided in Table 3.8 1.

Configuration Management

The configuration management program is required by 10 CFR 70.72 and establishes a system to evaluate, implement, and track each change to the site, structures, processes, systems, equipment, components, computer programs, and activities of personnel. Configuration management of IROFS, and any items that may affect the function of IROFS, is applied to all items identified within the scope of the IROFS boundary. Any change to structures, systems, equipment, components, and activities of personnel within the identified IROFS boundary must be evaluated before the change is implemented. If the change requires an amendment to the License, Nuclear Regulatory Commission approval is required prior to implementation.

Maintenance

Maintenance of IROFS, and any items that may affect the function of IROFS, encompasses planned surveillance testing and preventative maintenance, as well as unplanned corrective maintenance. Implementation of approved configuration management changes to hardware is also generally performed as a planned maintenance function.

Planned surveillance testing (e.g., functional/performance testing, instrument calibrations) monitors the integrity and capability of IROFS, and any items that may affect the function of IROFS, to ensure they are available and reliable to perform their function when needed, to comply with the performance requirements assumed in the ISA documentation. All necessary periodic surveillance testing is performed on an annual frequency (any exceptions credited within the ISA are discussed in Section 3.8.3).

Planned preventative maintenance (PM) includes periodic refurbishment, partial or complete overhaul, or replacement of IROFS, as necessary, to ensure the continued availability and reliability of the safety function assumed in the ISA documentation. In determining the frequency of any PM, consideration is given to appropriately balancing the objective of preventing failures through maintenance, against the objective of minimizing unavailability of IROFS because of PM. In addition, feedback from PM and corrective maintenance and the results of incident investigations and identified root causes are used, as appropriate, to modify the frequency or scope of PM.

Planned maintenance on IROFS, or any items that may affect the function of IROFS, that do not have redundant functions available, will provide for compensatory measures to be put into place to ensure that the IROFS function is performed until it is put back into service.

Corrective maintenance involves repair or replacement of equipment that has unexpectedly degraded or failed. Corrective maintenance restores the equipment to acceptable performance through a planned, systematic, controlled, and documented approach for the repair and replacement activities.

For an IROFS that is found to be degraded or impaired by planned operations, maintenance, or construction activities: a compensatory measure may be used to ensure that the function of the IROFS is compensated until it is returned to service. For example, a continuous fire watch may be used to compensate for a degraded IROFS barrier.

Following any maintenance on IROFS, and before returning an IROFS to operational status, functional testing of the IROFS, as necessary, is performed to ensure the IROFS is capable of performing its intended safety function.

Training and Qualifications

IROFS, and any items that may affect the function of IROFS, require that personnel involved at each level (from design through and including any assumed process implementation steps or actions) have and maintain the appropriate training and qualifications. Employees are provided with formal training to establish the knowledge foundation and on-the-job training to develop work performance skills. For process implemented steps or actions, a needs/job analysis is performed and tasks are identified to ensure that appropriate training is provided to personnel working on tasks related to IROFS. Minimum training requirements are developed for those positions whose activities are relied on for safety. Initial identification of job-specific training requirements is based on experience. Entry-level criteria (e.g., education, technical background, and/or experience) for these positions are contained in position descriptions.

Qualification is indicated by successful completion of prescribed training, demonstration of the ability to perform assigned tasks, and where required by regulation, maintaining a current and valid license or certification.

Continuing training is provided, as required, to maintain proficiency in specific knowledge and skill related activities. For all IROFS, and any items that may affect the function of IROFS, involving process implemented steps or actions, annual refresher training or requalification is required as identified in the needs/job analysis referenced in the previous paragraph. (any exceptions credited within the ISA are discussed in Section 3.8.3).

Procedures

All activities involving IROFS, and any items that may affect the function of IROFS, are conducted in accordance with approved procedures. Each of the other IROFS management measures (e.g., configuration management, maintenance, training) is implemented via approved procedures. These procedures are intended to provide a pre-planned method of conducting the activity in order to eliminate errors due to on-the-spot analysis and judgments.

All procedures are sufficiently detailed that qualified individuals can perform the required functions without direct supervision. However, written procedures cannot address all contingencies and operating conditions. Therefore, they contain a degree of flexibility appropriate to the activities being performed. Procedural guidance exists to identify the manner in which procedures are to be implemented. For example, routine procedural actions may not require the procedure to be present during implementation of the actions, while complex jobs, or checking with numerous sequences may require valve alignment checks, approved operator aids, or in-hand procedures that are referenced directly when the job is conducted.

To support the requirement to minimize challenges to IROFS, and any items that may affect the function of IROFS, specific procedures for abnormal events are also provided. These procedures are based on a sequence of observations and actions to prevent or mitigate the consequences of an abnormal situation.

Audits and Assessments

Audits are focused on verifying compliance with regulatory and procedural requirements and licensing commitments. Assessments are focused on effectiveness of activities and ensuring that IROFS are reliable and are available to perform their intended safety functions as documented in the ISA. The frequency of audits and assessments is based upon the status and safety importance of the activities being performed and upon work history. However, at a minimum, all activities associated with maintaining IROFS will be audited or assessed on an annual basis (any exceptions credited within the ISA are discussed in Section 3.8.3).

Incident Investigations

Incident investigations are conducted within the Corrective Action Program (CAP). Incidents associated with IROFS, and any items that may affect the function of IROFS, encompass a range of items, including (a) processes that behave in unexpected ways, (b) procedural activities not performed in accordance with the approved procedure, (c) discovered deficiency, degradation, or non-conformance with an IROFS, or any items that may affect the function of IROFS. Additionally, audit and assessment results are tracked in the Corrective Action Program.

Feedback from the results of incident investigations and identified root causes are used, as appropriate, to modify management measures to provided continued assurance that the reliability and availability of IROFS remain consistent with the performance requirements assumed in the ISA documentation.

Records Management

All records associated with IROFS, and any items that may affect the function of IROFS, shall be managed in a controlled and systematic manner in order to provide identifiable and retrievable documentation. Applicable design specifications, procurement documents, or other documents specify the QA records to be generated by, supplied to, or held, in accordance with approved procedures are included.

Other Quality Assurance Elements

Other quality assurance elements associated with IROFS, or any items that may affect the function of IROFS, that are required to ensure the IROFS is available and reliable to perform the function when needed to comply with the performance requirements assumed in the ISA documentation, will be listed in Table 3.8-1 and discussed in Section 3.8.3.

3.1.9 References

Edition of Codes, Standards, NRC Documents, etc that are not listed below are given in Table 3.0-1.

CFR, 2003a. Title 10, Code of Federal Regulations, Section 70.65, Additional content of applications, 2003.

CFR, 2003b. Title 10, Code of Federal Regulations, Part 70, Domestic Licensing of Special Nuclear Material, 2003.

CFR, 2003c. Title 10, Code of Federal Regulations, Section 70.61, Performance requirements, 2003.

CFR, 2003d. Title 10, Code of Federal Regulations, Section 70.24, Criticality accident requirements, 2003.

CFR, 2003e. Title 10, Code of Federal Regulations, Section 70.64, Requirements for new facilities or new processes at existing facilities, 2003.

CFR, 2003f. Title 10, Code of Federal Regulations, Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, 2003.

CFR, 2003g. Title 10, Code of Federal Regulations, Section 70.62, Safety program and integrated safety analysis, 2003.

CFR, 2003h. Title 29, Code of Federal Regulations, Section 1910, Occupational Safety and Health Standards, 2003.

CFR, 2003i. Title 10, Code of Federal Regulations, Section 70.72, Facility changes and change process, 2003.

LES, 1993. Claiborne Enrichment Center Safety Analysis Report, Louisiana Energy Services, December 1993.

3.1.10 Section 3.1 Tables

Table 3.1-1 HAZOP Guidewords

UF_6 PROCESS GUIDEWORDS			
Less Heat	Corrosion	Maintenance	No Flow
More Heat	Loss of Services	Criticality	Reverse Flow
Less Pressure	Toxicity	Effluents/Waste	Less Uranium
More Pressure	Contamination	Internal Missile	More Uranium
Impact/Drop	Loss of Containment	Less Flow	Light Gas
Fire (Process, internal, other)	Radiation	More Flow	External Event
NON UF_6 PROCESS GUIDEWORDS			
High Flow	Low Pressure	Impact/Drop	More Uranium
Low Flow	High Temperature	Corrosion	External Event
No Flow	Low Temperature	Loss of Services	Startup
Reverse Flow	Fire	Toxicity	Shutdown
High Level	High Contamination	Radiation	Internal Missile
Low Level	Rupture	Maintenance	
High Pressure	Loss of Containment	Criticality	
EXTERNAL EVENTS POTENTIAL CAUSES			
Construction on Site	Hurricane	Seismic	Transport Hazard Off-Site
Flooding	Industrial Hazard Off-site	Tornado	External Fire
Airplane	Snow/Ice	Local Intense Precipitation	

Table 3.1-2 ISA HAZOP Table Sample Format

ISA HAZOP NODE:		DESCRIPTION :			DATE:	PAGE:
GUIDEWORD	**HAZARD**	**CAUSE**	**CONSEQUENCE**	**SAFEGUARDS**	**MITIGATING FACTORS**	**COMMENTS**

Table 3.1-3 Consequence Severity Categories Based on 10 CFR 70.61

	Workers	Offsite Public	Environment
Category 3 High Consequence	Radiation Dose (RD) >1 Sievert (Sv) (100 rem) Chemical Dose (CD) > AEGL-3 for HF CD > AEGL-3 for U	RD > 0.25 Sv (25 rem) 30 mg sol U intake CD > AEGL-2	–
Category 2 Intermediate Consequence	0.25 Sv (25 rem) <RD≤ 1 Sv (100 rem) AEGL-2 < CD≤ AEGL-3 for HF AEGL-2 < CD ≤ AEGL-3 for U	0.05 Sv (5 rem) < RD≤ 0.25 Sv (25 rem) AEGL-1 <CD≤ AEGL-2	Radioactive release > 5000 x Table 2 Appendix B of 10 CFR Part 20
Category 1 Low Consequence	Accidents of lower radiological and chemical exposures than those above in this column	Accidents of lower radiological and chemical exposures than those above in this column	Radioactive releases with lower effects than those referenced above in this column

Notes:

*The worker that casues the release is expected to immediately sense and recognize the release and will not receive a dose significantly greater than a worker elsewhere in the area

Table 3.1-4 Chemical Dose Information

	High Consequence (Category 3)	**Intermediate Consequence (Category 2)**
Worker	> 146 mg U/m^3 > 139 mg HF/m^3	> 19 mg U/m^3 > 78 mg HF/m^3
Public (outside controlled area, 30-min exposure)	> 13 mg U/m^3 > 28 mg HF/m^3	> 2.4 mg U/m^3 > 0.8 mg HF/m^3

Table 3.1-5 Likelihood Categories Based on 10 CFR 70.61

	Likelihood Category	**Probability of Occurrence***
Not Unlikely	3	More than 10^{-4} per-event per-year
Unlikely	2	Between 10^{-4} and 10^{-5} per-event per-year
Highly Unlikely	1	Less than 10^{-5} per-event per-year

*Based on approximate order-of-magnitude ranges

Table 3.1-6 Risk Matrix with Risk Index Values

Severity of Consequences	Likelihood of Occurrence		
	Likelihood Category 1 Highly Unlikely (1)	Likelihood Category 2 Unlikely (2)	Likelihood Category 3 Not Unlikely (3)
Consequence Category 3 High (3)	Acceptable Risk 3	Unacceptable Risk 6	Unacceptable Risk 9
Consequence Category 2 Intermediate (2)	Acceptable Risk 2	Acceptable Risk 4	Unacceptable Risk 6
Consequence Category 1 Low (1)	Acceptable Risk 1	Acceptable Risk 2	Acceptable Risk 3

Table 3.1-7 (Not Used)

Table 3.1-8 Determination of Likelihood Category

Likelihood Category	Likelihood Index T (= sum of index numbers)
1	$T \leq -5$
2	$-5 < T \leq -4$
3	$-4 < T$

Table 3.1-9 Failure Frequency Index Numbers

Frequency Index No.	Based On Evidence	Based On Type Of IROFS**	Comments
-6*	External event with freq. < 10^{-6} /yr		If initiating event, no IROFS needed.
-5*	Initiating event with freq. < 10^{-5}/yr		For passive safe-by-design components or systems, failure is considered highly unlikely when no potential failure mode (e.g., bulging, corrosion, or leakage) exists, as discussed in Section 3.1.1.3.2, significant margin exists*** and these components and systems have been placed under configuration management.
-4*	No failures in 30 years for hundreds of similar IROFS in industry	Exceptionally robust passive engineered IROFS (PEC), or an inherently safe process, or two independent active engineered IROFS (AECs), PECs, or enhanced admin. IROFS	Rarely can be justified by evidence. Further, most types of single IROFS have been observed to fail
-3*	No failures in 30 years for tens of similar IROFS in industry	A single IROFS with redundant parts, each a PEC or AEC	
-2*	No failure of this type in this facility in 30 years	A single PEC	
-1*	A few failures may occur during facility lifetime	A single AEC, an enhanced admin. IROFS, an admin. IROFS with large margin, or a redundant admin. IROFS	
0	Failures occur every 1 to 3 years	A single administrative IROFS	
1	Several occurrences per year	Frequent event, inadequate IROFS	Not for IROFS, just initiating events

Table 3.1-9 Failure Frequency Index Numbers

Frequency Index No.	Based On Evidence	Based On Type Of IROFS**	Comments
2	Occurs every week or more often	Very frequent event, inadequate IROFS	Not for IROFS, just initiating events

*Indices less than (more negative than) –1 should not be assigned to IROFS unless the configuration management, auditing, and other management measures are of high quality, because, without these measures, the IROFS may be changed or not maintained.

**The index value assigned to an IROFS of a given type in column 3 may be one value higher or lower than the value given in column 1. Criteria justifying assignment of the lower (more negative) value should be given in the narrative describing ISA methods. Exceptions require individual justification.

***For components that are safe-by-volume, safe-by-diameter, or safe-by-slab thickness, significant margin is defined as a margin of at least 10%, during both normal and upset conditions, between the actual design parameter value of the component and the value of the critical design attribute. For components that require a more detailed criticality analysis, significant margin is defined as $k_{eff} < 0.95$, where $k_{eff} = k_{calc} + 3\sigma_{calc}$.

Table 3.1-10 Failure Probability Index Numbers

Probability Index No.	Probability of Failure on Demand	Based on Type of IROFS	Comments
-6*	10^{-6}		If initiating event, no IROFS needed.
-4 or -5*	10^{-4} - 10^{-5}	Exceptionally robust passive engineered IROFS (PEC), or an inherently safe process, or two redundant IROFS more robust than simple admin. IROFS (AEC, PEC, or enhanced admin.)	Can rarely be justified by evidence. Most types of single IROFS have been observed to fail
-3 or -4*	10^{-3} - 10^{-4}	A single passive engineered IROFS (PEC) or an active engineered IROFS (AEC) with high availability	
-2 or -3*	10^{-2} - 10^{-3}	A single active engineered IROFS, or an enhanced admin. IROFS, or an admin. IROFS for routine planned operations	
-1 or -2	10^{-1} - 10^{-2}	An admin. IROFS that must be performed in response to a rare unplanned demand	

*Indices less than (more negative than) –1 should not be assigned to IROFS unless the configuration management, auditing, and other management measures are of high quality, because, without these measures, the IROFS may be changed or not maintained.

Table 3.1-11 Failure Duration Index Numbers

Duration Index No.	Avg. Failure Duration	Duration in Years	Comments
1	More than 3 yrs	10	
0	1 yr	1	
-1	1 mo	0.1	Formal monitoring to justify indices less than -1
-2	A few days	0.01	
-3	8 hrs	0.001	
-4	1 hr	10^{-4}	
-5	5 min	10^{-5}	

3.2 SITE DESCRIPTION

This section provides an overall description of the National Enrichment Facility (NEF) site and its environment, including regional and local geography, demography, meteorology, hydrology, geology, seismology, and stability of subsurface materials. Significant portions of the information presented in this section were derived from the NEF Environmental Report (LES, 2003).

This section also provides a characterization of natural phenomena (e.g., tornadoes, hurricanes, floods, and earthquakes) and other external events (e.g., explosions and aircraft crashes) in sufficient detail to assess their impact on facility safety and to assess their likelihood of occurrence.

3.2.1 Site Geography

Site features are well suited for the location of an uranium enrichment facility as evidenced by favorable conditions of hydrology, geology, seismology and meteorology as well as good transportation routes for distributing feed and product by truck.

3.2.1.1 Site Location

The proposed NEF site is located in Southeastern New Mexico near the New Mexico/Texas state line, in Lea County. This location is about 8 km (5 mi) east of Eunice and about 32 km (20 mi) south of Hobbs. The site comprises about 220 ha (543 acres) and is within county Section 32, Township 21 South, Range 38 East. The approximate center of the NEF is at latitude 32 degrees, 26 min, 1.74 sec North and longitude 103 degrees, 4 min, 43.47 sec West (see Figure 3.2-1, County Map).

Section 32 is currently owned by the State of New Mexico. The State of New Mexico has granted a 35 year easement to LES for site access and control.

The NEF site is relatively flat with slight undulations in elevation ranging from 1,033 to 1,045 m (3,390 to 3,430 ft) above mean sea level. The overall slope direction is to the southwest. Except for a gravel covered road which bisects the east and west halves of Section 32, the property is undeveloped and utilized for domestic livestock grazing (see Figure 3.2-2, Plot Plan).

Figure 3.2-3, Site Plan, shows the site property boundary and the general layout of the buildings.

3.2.1.2 Public Roads and Transportation

3.2.1.2.1 Public Roads

The site lies along the north side of New Mexico Highway 234. New Mexico Highway 234 intersects New Mexico Highway 18 about 4 km (2.5 mi) to the west. (See Figure 3.2-1). To the north, U.S. Highway 62/180 intersects New Mexico Highway 18 providing access from the city of Hobbs south to New Mexico Highway 234. To the east in Texas, U.S. Highway 385 intersects Texas Highway 176 providing access from the town of Andrews west to New Mexico Highway 234. To the south in Texas, Interstate 20 intersects Texas Highway 18 which becomes New Mexico Highway 18. West of the site, New Mexico Highway 8 provides access from the city of Eunice east to New Mexico Highway 234.

Potential adverse impact to NEF from chemical releases or explosions from trucks on nearby highways was evaluated. Due to the distance of the highway from the facility boundary, a chemical release from a passing vehicle will not have a safety impact on facility operations. Detailed probabilistic analyses show the annual probability of an explosion adversely impacting the plant is less than 1.0 E-5 per year.

3.2.1.2.2 Railroads

The nearest active rail transportation (the Texas-New Mexico Railroad) is in Eunice, New Mexico to the west about 5.8 km (3.6 mi) from the site. This rail line is used mainly by the local oil and gas industry for freight transport. There is also a rail spur to the Waste Control Specialists (WCS) facility along the northern boundary of the NEF site about 1 km (0.5 mi) from the Separations Building Module (SBM). This spur does not transport explosive materials or chemical shipments which could have a safety impact on facility operations. As such, there is no railroad traffic within proximity to the facility which poses a safety concern.

3.2.1.2.3 Water Transportation

There are no navigable waterways in the vicinity of the site.

3.2.1.2.4 Air Transportation

The nearest airport facilities are located just west of Eunice and are maintained by Lea County. The airport is about 16 km (10 mi) west of the proposed NEF and consists of two runways measuring about 1,000 m (3,280 ft) and 780 m (2,550 ft) each. Privately owned planes are the primary users of the airport. There is no control tower and no commercial air carrier flights (DOT, 2003). The nearest major commercial carrier airport is Lea County Regional Airport in Hobbs, New Mexico, about 32 km (20 mi) north.

An aircraft hazard analysis has been performed for the facility site, following the methodology of NUREG-0800. Airports and airways in the vicinity of the site have been identified. Based on the published number of operations and distance to the proposed site, it is concluded that the presence of these airports does not pose any risk to the site with regard to aircraft hazard. For the identified airways, the probability of aircraft along these airways crashing onto the proposed site has been conservatively calculated to be less than 1.0 E-6 per year.

3.2.1.3 Nearby Bodies of Water

The climate in southeast New Mexico is semi-arid. Average precipitation at the site is calculated to be 33 to 38 cm (13 to 15 in) per year. Evaporation and transpiration rates are high. This results in minimal, if any, surface water occurrence.

The NEF site contains no surface drainage features. The site topography is relatively flat. Some localized depressions exist due to eolian processes, but the size of these features is too small to be of significance with respect to surface water collection.

The closest water conveyance is Monument Draw, a typically dry, intermittent stream located several miles west of the site.

Baker Spring, an intermittent surface water feature, is situated a little over 1.6 km (1 mi) northeast of the NEF site.

There are also three "produced water" lagoons for industrial purposes on the adjacent quarry property to the north.

There is also a manmade pond at the Eunice golf course approximately 15 km (9.5 mi) west of the site.

3.2.2 Demographics and Land Use

This section provides the census results for the site area, specific information about nearby population areas with respect to proximity to the site, specific information about nearby public facilities (schools, hospitals, parks, etc.) with respect to proximity to the site, and land and water use near the site.

3.2.2.1 Population Information

This section describes the population characteristics of the two-county areas around the NEF site.

3.2.2.1.1 Permanent Population and Distribution

The combined population of the two counties in the NEF vicinity, based on the 2000 U.S. Census is 68,515, which represents a 2.3% decrease over the 1990 population of 70,130 (Table 3.2-1, Population and Population Projections, 1970-2040). This rate of decrease is counter to the trends for the states of New Mexico and Texas, which had population increases of 20.1% and 22.8%, respectively during the same decade. Over that 10 year period, Lea County, New Mexico, where the site is located, had a growth decrease of 0.5% and the Andrews County, Texas decrease was 9.3%. Lea County experienced a sharp but short population increase in the mid-1980's due to petroleum industry jobs. The change in the job market caused the population in Lea County to increase to over 65,000 during that period.

Based on projections made using historic data (Table 3.2-1), Lea County, New Mexico and Andrews County, Texas are likely to grow more slowly than their respective states over the next 30 years (the expected licensed period for the NEF).

Lea County covers 11,378 km^2 (4,393 mi^2) or approximately 1,142,238 ha (2,822,522 acres) which is three times the size of Rhode Island and only slightly smaller than Connecticut. The county population density is 16% lower than the New Mexico state average (4.8 versus 5.8 people per square kilometer (12.6 versus 15.0 people per square mile)). The county housing density is 20% lower than the New Mexico state average (2.0 versus 2.5 housing units per square kilometer (5.3 versus 6.4 housing units per square mile)).

Andrews County covers 3,895 km^2 (1,504 mi^2). The county population density is 11% of the Texas state average (3.3 versus 30.6 per square kilometer (8.7 versus 79.6 population density per square mile)). The county housing density is low, at just over 11% of the Texas state average (1.4 versus 12.0 housing units per square kilometer (3.6 versus 31.2 housing units per square mile)).

3.2.2.1.2 Industrial Population

More than 98% of the area within an 8 km (5 mi) radius of the NEF is an extensive area of open land on which livestock wander and graze. Gas and oil field operations are widespread in the area, but significant petroleum potential is absent within at least 5 to 8 km (3 to 5 mi) of the site. Industrial operations near the site include:

- A quarry, operated by Wallach Concrete, Inc., and several oil recovery sludge ponds owned by the Sundance Services are located north of the site. The quarry owner leases land space to a "produced water" reclamation company that maintains three small "produced water" lagoons. Eight people are employed at the Wallach Concrete Quarry and nine people are employed by Sundance Services.
- Lea County operates a landfill on the south side of New Mexico State Highway 234, approximately 1 km (0.6 mi) from the center of Section 32. Four people are employed at the Lea County landfill.
- A vacant parcel of land is immediately east of the site. Land further east approximately 1.6 km (1 mi), in Texas, is occupied by Waste Control Specialists (WCS), LLC. WCS possesses a radioactive materials license from Texas, an NRC Agreement state. WCS is licensed to treat and temporarily store low-level and mixed low-level radioactive waste. WCS is also permitted to treat and dispose of hazardous toxic waste in a landfill. WCS employs 72 people.
- Dynegy's Midstream Services Plant is located 6 km (4 mi) from the site. This facility is engaged in the gathering and processing of natural gas. The Dynegy Midstream Services Plant employs 40 people.

3.2.2.2 Population Centers

The proposed NEF site is in Lea County, New Mexico, approximately 1 km (0.6 mi) from the border of Andrews County, Texas, as shown on Figure 3.2-1. The figure also shows the city of Eunice, New Mexico, the closest population center to the site, at a distance of about 8 km (5 mi). Other population centers are at distances from the site as follows:

- Hobbs, Lea County, New Mexico: 32 km (20 mi) north
- Jal, Lea County, New Mexico: 37 km (23 mi) south
- Lovington, Lea County New Mexico: 64 km (39 mi) north-northwest
- Andrews, Andrews County Teas: 51 km (32 mi) east
- Seminole, Gaines County Texas, 51 km (32 mi) east-northeast
- Denver City, Gaines County, Texas 65 km (40 mi) north-northeast.

Aside from these communities, the population density in the site region is extremely low. Table 3.2-1, lists by year/decade, the estimated population in the site vicinity.

3.2.2.3 Public Service Facilities

3.2.2.3.1 Fire Department and Local Law Enforcement

Fire support service for the Eunice area is provided by Eunice Fire and Rescue, located approximately 8 km (5 mi) from the site. If additional fire equipment is needed, or if Eunice Fire and Rescue is unavailable, mutual aid agreements exist with all of the county fire departments.

The Eunice Police Department, with five full-time officers, provides local law enforcement. The Lea County Sheriff's Department also maintains a substation in Eunice. If additional resources are needed, officers from mutual aid communities within Lea County and Andrews County, Texas, can provide an additional level of response. The New Mexico State Police provide a third level of response.

3.2.2.3.2 School Population

There are four educational institutions within a radius of about 8 km (5 mi) of the NEF site, all in Lea County, New Mexico. These include an elementary school, a middle school, a high school and a private K-12 school. Table 3.2-2, Educational Facilities Near the Site, details the location of the educational facilities, population (including faculty/staff members), and student-teacher ratio. Apart from these schools, the next closest educational institutions are in Hobbs, New Mexico, 32 km (20 mi) north of the site.

The closest schools in Andrews County, Texas are in the community of Andrews about 51 km (32 mi) east of the NEF site.

3.2.2.3.3 Health Care Populations

There are two hospitals in Lea County, New Mexico. The Lea Regional Medical Center is located in Hobbs, New Mexico, about 32 km (20 mi) north of the proposed NEF site. This 250-bed hospital can handle acute and stable chronic care patients. In Lovington, New Mexico, 64 km (39 mi) north-northwest of the site, Covenant Medical Systems manages Nor-Lea Hospital, a full-service, 27-bed facility.

There are no nursing homes or retirement facilities in the site area. The closest such facilities are in Hobbs, New Mexico, about 32 km (20 mi) north of the site.

3.2.2.3.4 Recreational Population

There are no recreational facilities near the site. The Eunice Golf Course is located approximately 15 km (9.2 mi) from the site. A historical marker and picnic area is located about 3.2 km (2 mi) from the site at the intersection of New Mexico Highways 234 and 18.

3.2.2.4 Industrial Areas

More than 98% of the area within an 8 km (5 mi) radius of the NEF is an extensive area of open land on which livestock wander and graze. Gas and oil field operations are widespread in the area, but significant petroleum potential is absent within at least 5 to 8 km (3 to 5 mi) of the site. Industrial operations near the site include:

- A quarry, operated by Wallach Concrete, Inc., and several oil recovery sludge ponds owned by the Sundance Services are located north of the site. The quarry owner leases land space to a "produced water" reclamation company that maintains three small "produced water" lagoons. The operations at these facilities do not pose a safety concern for the NEF.
- Lea County operates a landfill on the south side of New Mexico State Highway 234, approximately 1 km (0.6 mi) from the center of Section 32. This facility does not pose a safety concern for the NEF.
- A vacant parcel of land is immediately east of the site. Land further east approximately 1.6 km (1 mi), in Texas, is occupied by WCS. WCS possesses a radioactive materials license from Texas, an NRC Agreement state. WCS is licensed to treat and temporarily store low-level and mixed low-level radioactive waste. WCS is also permitted to treat and dispose of hazardous toxic waste in a landfill. WCS does not pose a safety concern for the NEF.
- Dynegy's Midstream Services Plant is located 6 km (4 mi) from the site. This facility is engaged in the gathering and processing of natural gas.
- An underground CO2 pipeline originally traversed the property in a southeast-northwest direction. The 254 mm (10 in) diameter pipe operated at 134.4 bar (1,950 psi). The pipeline has been relocated along the western and southern boundary of Section 32 so that it will be at least 381 m (1,250 ft) from the facility Restricted Area. At this distance from the facility, the pipeline does not pose a safety concern.
- An underground natural gas pipeline is located along the south property line, paralleling New Mexico Highway 234. A risk assessment of the hazards posed by the pipeline has been performed. The assessment used a hazard model to estimate the likelihood of a gas line leak and subsequent explosion that could impact NEF operations. The model incorporated historical data on pipeline accidents obtained from the Department of Transportation (DOT, 2002) and accounted for the conditional probability that if an explosion were to occur, it would have to be substantial to have an impact on facility buildings. The model also accounted for the safe separation distance, i.e., if an explosion occurs beyond the safe separation distance for a critical structure, then the structure will be unaffected. The calculated probability of the hazard due to the natural gas pipeline in the vicinity of the proposed NEF is 9.4 E-6 per year.

3.2.2.5 Land Use

Surrounding property consists of vacant land and industrial developments. A railroad spur borders the site to the north. Beyond is a sand/aggregate quarry. A vacant parcel of land is situated immediately to the east. Cattle grazing are not allowed on this vacant parcel. Further east, at the state line and within Andrews County, Texas, is a hazardous waste treatment and disposal facility. A landfill is south-southeast of the site, across New Mexico Highway 234 and a petroleum contaminated soil treatment facility is adjacent to the west. Land further north, south and west has been mostly developed by the oil and gas industry. Land further east is ranchland. The nearest residences are situated approximately 4.3 km (2.63 mi) west of the site. Beyond is the city of Eunice, which is approximately 8 km (5 mi) to the west. There are no known public recreational areas with 8 km (5 mi) of the site. There is a historical marker and picnic area approximately 3.2 km (2 mi) from the site at the intersection of New Mexico Highways 234 and 18. Refer to Section 3.2.5.2 for further discussion on mineral resources in the site vicinity.

Rangeland comprises 98.5% of the area within an 8 km (5 mi) radius of the NEF site, encompassing 12,714 ha (31,415 acres) within Lea County, New Mexico, and 7,213 ha (17,823 acres) in Andrews County, Texas. Rangeland is an extensive area of open land on which livestock wander and graze and includes herbaceous rangeland, shrub and brush rangeland and mixed rangeland. Built-up land and barren land constitute the other two land use classifications in the site vicinity, but at considerably smaller percentages. Land cover due to built-up areas, which includes residential and industrial developments, makes up 1.2 percent of the land use. This equates to a combined total of 243 ha (601 acres) for Lea and Andrews Counties. The remaining 0.3% of land area is considered barren land which consists of bare exposed rock, transitional areas and sandy areas. This information is summarized in Table 3.2-3, Land Use Within 8 km (5 mi) of the Site. The above indicated land use classifications are identical to those used by the United States Geological Survey (USGS). No special land use classifications (i.e., Native American reservations, national parks, prime farmland) are within the vicinity of the site.

Except for the proposed construction of the NEF and the potential citing of a low-level radioactive waste disposal site in Andrews County, Texas, there are not other know current, future or proposed land use plans, including staged plans, for the site or immediate vicinity.

3.2.2.6 Water Use

The climate in southeast New Mexico is semi-arid. Average precipitation at the site is calculated to be only 33 to 38 cm (13 to 15 in) per year. The NEF site itself contains no surface water bodies or surface drainage features. Essentially all the precipitation that occurs at the site is subject to infiltration and/or evapotranspiration.

3.2.2.6.1 Recreation

There are no significant bodies of water or navigable waterways in the vicinity of the site.

3.2.2.6.2 Agricultural Water Use

Although various crops are grown within Lea and Andrews Counties, local and county officials report that there is no agricultural activity in the site vicinity, except for domestic livestock ranching. The principal livestock for both Lea and Andrews Counties is cattle. Although milk cows comprise a significant number of cattle in Lea County, the nearest dairy farms are about 32 km (20 mi) north of the subject site, near the city of Hobbs, New Mexico. There are no milk cows in Andrews County. Table 3.2-4, Agriculture Census, Crop, and Livestock Information, provides data on agricultural and livestock activities in Lea County, New Mexico, and Andrews County, Texas.

Known sources of water in the site vicinity include the following: a manmade pond on the adjacent quarry property to the north which is stocked with fish for private use; Baker Spring, an intermittent surface water feature, situated a little over 1.6 km (1 mi) northeast of the site which only contains water seasonally; several cattle watering holes where groundwater is pumped by windmill and stored in above ground tanks.

3.2.2.6.3 Municipal Use of Local Surface Water

Surface water is not a source of water for municipal use.

3.2.2.6.4 Groundwater Use

The NEF water supply is from the municipal water system in Eunice, New Mexico, and thus no water will be drawn from either surface water or groundwater sources at the NEF site. The Eunice system obtains water from a groundwater source in the city of Hobbs, approximately 32 km (20 mi) north of the site. Supply of nearby groundwater users will thus not be affected by operation of the NEF. No subsurface or surface water uses such as withdrawals or consumption are made at the site by the NEF.

3.2.3 Meteorology

In this section, data characterizing the meteorology (e.g., wind, precipitation, and severe weather) for the site are presented. The discussion identifies the design basis natural events for the facility, including the likelihood of occurrence.

The meteorological conditions at the NEF have been evaluated and summarized in order to characterize the site climatology and to provide a basis for predicting the dispersion of gaseous effluents. No on-site meteorological data were available, however, WCS have a meteorological monitoring station within approximately 1.6 km (1 mi) from the proposed NEF site.

Climate information from Hobbs, New Mexico (32 km (20 mi) north of the site), obtained from the Western Regional Climate Center, were used. In addition, National Oceanic and Atmospheric Administration (NOAA) Local Climatological Data (LCD) recorded at Midland-Odessa Regional Airport, Texas (103 km (64 mi) southeast of the site) and at Roswell, New Mexico (161 km (100 mi) northwest of the site) were used. In the following summaries of meteorological data, the averages are based on:

- Hobbs station (WRCC, 2003) averages are based on a 30 year record (1971 to 2000) unless otherwise stated

- Midland-Odessa station (NOAA, 2002a) averages are based on a 30 year record (1961 to 1990) unless otherwise stated
- Roswell station (NOAA, 2002b) averages are based on a 30 year record (1961 to 1990) unless otherwise stated.

The WCS data was not used since it had not been fully verified by WCS. An analysis of the WCS data was performed and it was determined that the prevailing wind direction at the WCS facility agrees with the prevailing wind directions at Midland-Odessa and Roswell. Use of the Hobbs, Midland-Odessa, and Roswell observations for a general description of the meteorological conditions at the NEF was deemed appropriate as they are all located within the same region and have similar climates. Use of the Midland-Odessa data for predicting the dispersion of gaseous effluents was deemed appropriate. It is the closest first-order National Weather Service (NWS) station to the NEF site, and both Midland-Odessa and the NEF site have similar climates. In addition, wind direction frequency comparisons between Midland-Odessa and the closest source of meteorological measurements (WCS) to the NEF site show good agreement. Midland-Odessa and Roswell data were compiled and certified by the National Climatic Data Center. Hobbs data were compiled and certified by the Western Regional Climate Center.

3.2.3.1 Local Wind Patterns and Average and Maximum Wind Speeds

Monthly mean wind speeds and prevailing wind directions at Midland-Odessa are presented in Table 3.2-5, Midland-Odessa, Texas, Wind Data. The annual mean wind speed was 4.9 m/s (11.0 mi/hr) and the prevailing wind direction was 180 degrees with respect to true north. The maximum five-second wind speed was 31.3 m/s (70 mi/hr).

Monthly mean wind speeds and prevailing wind directions at Roswell are presented in Table 3.2-6, Roswell, New Mexico, Wind Data. The annual mean wind speed was 3.7 m/s (8.2 mi/hr) and the prevailing wind direction was wind from 160 degrees with respect to true north. The maximum five-second wind speed was 27.7 m/s (62 mi/hr).

Five years of data (1987-1991) from the Midland-Odessa NWS were used to generate joint frequency distributions of wind speed and direction. This data summary, for all Pasquill stability classes (A-F) combined, is provided in Table 3.2-7, Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution For All Stability Classes Combined.

Five years of data (1987-1991) from the Midland-Odessa NWS were used to generate joint frequency distributions of wind speed and direction as a function of Pasquill stability class (A-F). Stability class was determined using the solar radiation/cloud cover method. These data are given in Tables 3.2-8 through 3.2-13. The most stable classes, E and F, occur 18.3% and 13.6% of the time, respectively. The least stable class, A, occurs 0.4% of the time. Important conditions for atmospheric dispersion, stable (Pasquill class F) and low wind speeds 0.4-1.3 m/s (1.0-3.0 mi/hr), occur 2.2% of the time. The highest occurrences of Pasquill class F and low wind speeds, 0.4-1.3 m/s (1.0-3.0 mi/hr), with respect to wind direction are 0.28% and 0.23% with south and south-southeast winds.

3.2.3.2 Annual Amounts and Forms of Precipitation

The normal annual total rainfall as measured in Hobbs is 46.1 cm (18.15 in). Precipitation amounts range from an average of 1.2 cm (0.45 in) in March to 8 cm (3.1 in) in September. The record maximum and minimum monthly totals are 35.13 cm (13.83 in) and zero, respectively (WRCC, 2003). Table 3.2-14, Hobbs New Mexico Temperature and Precipitation Data, lists the monthly averages and extremes of precipitation for the Hobbs data. These precipitation summaries are based on 30 year records.

The normal annual total rainfall as measured in Midland-Odessa is 37.6 cm (14.8 in). Precipitation amounts range from an average of 1.1 cm (0.42 in) in March to 5.9 cm (2.31 in) in September. The record maximum and minimum monthly totals are 24.6 cm (9.70 in) and zero, respectively. The highest 24-hour precipitation total was 15.2 cm (6 in) in July 1968 (NOAA, 2002a). Table 3.2-15, Midland-Odessa, Texas, Precipitation Data, lists the monthly averages and extremes of precipitation for the Midland-Odessa data. These precipitation summaries are based on 30 year records.

The normal annual rainfall total as measured in Roswell, New Mexico, is 33.9 cm (13.34 in). The record maximum and minimum monthly totals are 17.5 cm (6.9 in) and zero, respectively (NOAA, 2002b, 2002a). The highest 24-hour precipitation total was 12.5 cm (4.91 in) in July 1981 (NOAA, 2002b). Table 3.2-16, Roswell, New Mexico, Precipitation Data, lists the monthly averages and extremes of precipitation for the Roswell data. These precipitation summaries are based on 30 year records.

3.2.3.3 Design Basis Values for Snow or Ice Load

Snowfall in Midland-Odessa, Texas, averages 13.0 cm (5.1 in) per year. Maximum monthly snowfall/ice pellets of 24.9 cm (9.8 in) fell in December 1998. The maximum amount of snowfall/ice pellets to fall in 24 hours was 24.9 cm (9.8 in) in December 1998 (NOAA, 2002a). Table 3.2-17, Midland-Odessa, Texas, Snowfall Data, lists the monthly averages and maximums of snowfall/ice pellets at Midland-Odessa, Texas. These snowfall summaries are based on 30 year records.

Snowfall in Roswell, New Mexico, averages 30.2 cm (11.9 in) per year. Maximum monthly snowfall/ice pellets of 53.3 cm (21.0 in) fell in December 1997. The maximum amount of snowfall/ice pellets to fall in 24 hours was 41.9 cm (16.5 in) in February 1988 (NOAA, 2002b). Table 3.2-18, Roswell, New Mexico, Snowfall Data, lists the monthly averages and maximums of snowfall/ice pellets at Roswell, New Mexico. These snowfall summaries are based on 30 year records.

The design basis ground snow load for the NEF was determined by combining the 100-year snowpack loading and 48 hour Probable Maximum Winter Precipitation (PMWP) loading for the area. Using the published 50 year snowpack loading of 48.8 kg/m^2 (10 lb/ft^2) (ASCE 7) and adjusting this value using the method described by ASCE, the 100 year snowpack loading is determined to be 58.6 kg/m^2 (12 lb/ft^2).

The 48-hour PMWP as determined by the methodology outlined in Hydrometeorlogical Report No. 33 (WB, 1956) is determined to be 483 mm (19 in), which corresponds to a loading of 96.6 kg/m^2 (19.8 lb/ft^2). These two values were used to develop a design basis ground snow loading of 156 kg/m^2 (32 lb/ft^2).

The design basis ground snow load does not explicitly account for loads due to frozen rain, ice, or hail. This type of loading is bounded by the conservative design basis ground snow load discussed above.

3.2.3.4 Type, Frequency, and Magnitude of Severe Weather

This section identifies the design basis severe weather events for the facility and describes the basis for their selection.

3.2.3.4.1 Tornados and Tornado Missiles

Tornadoes occur infrequently in the vicinity of the NEF. Only two significant tornadoes (i.e., F2 or greater) were reported in Lea County, New Mexico, (Grazulis, 1993) from 1880-1989. Across the state line, only one significant tornado was reported in Andrews County, Texas, (Grazulis, 1993) from 1880-1989.

Tornadoes are commonly classified by their intensities. The F-Scale classification of tornados is based on the appearance of the damage that the tornado causes. There are six classifications, F0 to F5, with an F0 tornado having winds of 64-116 km/hr (40-72 mi/hr) and an F5 tornado having winds of 420–512 km/hr (261-318 mi/hr) (AMS, 1996). The two tornadoes reported in Lea County were estimated to be F2 tornadoes (Grazulis, 1993).

The following steps were taken in performing the tornado hazard assessment for the site:

- Define a local region of latitude and longitude that surrounds the site of interest and obtain historical records of tornadoes that have touched down in the local region
- Determine occurrence rate and associated confidence limits
- Determine number of tornadoes per F-Scale category
- Estimate the damage path area for each F-Scale category and calculate damage areas associated with confidence limits
- Calculate tornado hazard probabilities for each F-Scale wind speed category.

An annual tornado hazard probability of 1E-05 was chosen for the design basis tornado. The tornado and tornado missile parameters from the site-specific study are provided below.

Annual Tornado Hazard Probability	1E-05
Tornado Wind Speed	302 km/hr (188 mi/hr)
Radius of Damaging Winds	130 m (425 ft)
Atmospheric Pressure Change (APC)	-390 kg/m^2(-80 lb/ft^2)
Rate of APC	-146 kg/m^2/s (-30 lb/ ft^2)
Missile: 2x4 Timber Plank, 6.80 kg (15 lb)	
Horizontal Speed	136 km/hr (85 mi/hr)
Vertical Speed	88 km/hr (55 mi/hr)
Maximum Height above Ground	61 m (200 ft)

Missile: 76.2 mm (3-in.) Diameter Steel Pipe, 34 kg (75 lb)	
Horizontal Speed	80 km/hr (50 mi/hr)
Vertical Speed	48 km/hr (30 mi/hr)
Maximum height above Ground	9.1 m (30 ft)
Missile: Automobile 1361 kg (3,000 lb)	
Horizontal Speed	32 km/hr (20 mi/hr)

3.2.3.4.2 Extreme Winds

Annual extreme winds recorded at the Midland-Odessa, Texas, airport are used to model the straight wind hazard at the NEF site. The airport is located 103 km (64 mi) east-southeast of the site. The airport location features flat, open terrain. Due to proximity, common weather systems affect Eunice, New Mexico, and Midland-Odessa, Texas. The wind speeds used in the model are 3 second gust speeds at a 10 m height above ground. The set of annual extreme winds include the years 1973 to 1999.

A Fischer-Tippett Type I extreme value distribution is fit to the annual extreme wind speed data. Upper and lower bound values at 95% confidence level are also calculated. The results of the straight wind hazard assessment are provided in Table 3.2-19, Straight Wind Hazard Assessment.

An annual wind hazard probability of 1E-05 was chosen for the design basis wind speed. This wind speed is 252 km/hr (157 mi/hr), and is a 3 second gust, 10 m (33 ft) above ground.

3.2.3.4.3 Hurricanes

Hurricanes, or tropical cyclones, are low-pressure weather systems that develop over the tropical oceans. These storms are classified during their life cycle according to their intensity:

- Tropical depression – wind speeds less than 63 km/hr (39 mi/hr)
- Tropical storm – wind speed between 63 and 118 km/hr (39 and 73 mi/hr)
- Hurricane – wind speeds greater than 118 km/hr (73 mi/hr)

Hurricanes are fueled by the relatively warm tropical ocean water and lose their intensity quickly once they make landfall. Since the NEF is sited about 805 km (500 mi) from the coast, it is most likely that any hurricane that is tracked towards it would have dissipated to the tropical depression stage, that is, wind speeds less than 63 km/hr (39 mi/hr), before it reached the NEF. Therefore hurricanes are not a design basis event for the site.

3.2.3.4.4 Extreme Precipitation

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

Roofs will be designed so as not to pond water to a depth during the local intense PMP that could exceed the design load for the roof.

Local site runoff has been determined for the local plant site drainage area. Maximum ponding depths around the main plant structures is approximately 49 cm (1.9 ft) using final site topography. Although the potential for water intrusion into critical plant areas will be precluded by final site grading, criticality analysis conservatively assumes 60 cm (2 ft) of flooding.

3.2.3.4.5 Lightning

Thunderstorms occur during every month but are most common in the spring and summer months. Thunderstorms occur an average of 36.4 days/year in Midland-Odessa, Texas, based on a 54 year period of record. The seasonal averages are: 11 days in spring (March through May); 17.4 days in summer (June through August); 6.7 days in fall (September through November); and 1.3 days in winter (December through February).

J. L. Marshall (Marshall, 1973) presented a methodology for estimating lightning strike frequencies which includes consideration of the attractive area of structures. His method consists of determining the number of lightning flashes to earth per year per square kilometer and then defining an area over which the structure can be expected to attract a lightning strike. Assuming that there are 4 flashes to earth per year per square kilometer (10.36 flashes to earth per year per square mile) in the vicinity of the NEF (conservatively estimated using Figure 3.2-4, Average Lightning Flash Density, which is taken from the NWS (NWS, 2003). Marshall defines the total attractive area, A, of a structure with length L, width W, and height H, for lightning flashes with a current magnitude of 50% of all lightning flashes as:

$$A = LW + 4H (L + W) + 12.57 H2$$

The following building complex dimensions were used to estimate conservatively the attractive area of the NEF:

$$L = 534 \text{ m } (1{,}752 \text{ ft}),\ W = 534 \text{ m } (1{,}752 \text{ ft}),\ H = 20^1/_4 \text{ m } (66^1/_2 \text{ ft})$$

The total attractive area is therefore equal to 0.34 km^2 (0.1455 mi^2). Consequently, the lightning strike frequency computed using Marshall's methodology is given as 1.51 flashes per year.

Lightning protection for the NEF is provided.

3.2.4 Hydrology

This section describes the NEF site's surface water and groundwater resources. Data is provided for the NEF site and the surrounding area, and the regional associations of those natural water systems are described. This information provides the basis for evaluation of any potential facility impacts on surface water, aquifers, and the related social and economic structures of the area around the facility.

The information included in this section was largely obtained from prior site studies including extensive subsurface investigations for a nearby facility, WCS, located about 1.6 km (1 mi) to the east of the NEF site. In addition, literature searches were conducted to obtain additional reference material. Some of the WCS data has been collected on Section 33 located immediately east of the NEF site. These data are being supplemented by a groundwater exploration and sampling program on Section 32 initiated by LES in September 2003.

The NEF facility will make no use of either surface water or groundwater from the site. The collection and storage of runoff from specific site areas will be controlled. No significant adverse changes are expected in site hydrology as a result of construction or operation of the NEF.

3.2.4.1 Surface Hydrology

The NEF site itself contains no surface water bodies or surface drainage features. Essentially all the precipitation that occurs at the site is subject to infiltration and/or evapotranspiration. More information on the movement and fate of surface water and groundwater at the site is provided in the following sections.

3.2.4.2 Major Surface and Subsurface Hydrological Systems

The climate in southeast New Mexico is semi-arid. Average precipitation at the site is calculated to be 33 to 38 cm per year (13 to 15 in per year). Evaporation and transpiration rates are high. This results in minimal, if any, surface water occurrence or groundwater recharge.

The NEF site is relatively flat and contains no surface drainage features.. Some localized depressions exist, due to eolian processes, but the size of these features is too small to be of significance with respect to surface water collection.

Most precipitation is contained onsite due to infiltration and/or evapotranspiration. The vegetation on the site is primarily mesquite bush (Prosopis juliflora) and native grasses (e.g., Sporobolus giganteus). The surface soils are predominantly of an alluvial or eolian origin. The texture of the surface soils is generally silt to silty sands. Therefore, the surface soils are relatively low in permeability and tend to hold moisture in storage rather than allow rapid infiltration to depth. Water held in storage in the soil is subsequently subject to evapotranspiration. Nine preliminary subsurface borings were drilled at the site during September 2003. Only one of the borings produced cuttings that were slightly moist at 1.8 to 4.2 m (6 to 14 ft) below ground surface; other cuttings were very dry. Also, ground water was not encountered during drilling in any of the additional 59 NEF site borings, which are documented in Appendices A and C of the Geotechnical Report (NTS Report No. 114489-G-01, Rev. 00) and some of which were drilled as deep as 30.5 m (100 ft) below grade. Evapotranspiration processes are significant enough to short-circuit any potential groundwater recharge. This process is further discussed below.

There is some evidence for shallow, near-surface groundwater occurrence in areas to the north and east of the site. These conditions are intermittent and limited. A quarry operated by Wallach Concrete, Inc. is located just north of the NEF site. Wallach Concrete has extensively mined sand and gravel from the quarry. The typical geologic cross section at that site consists of a layer of caliche at the surface, referred to as the "caprock," underlain by a sand and gravel deposit, which in turn overlies a thick clay unit of the Dockum Group, referred to as red beds, and part of the Chinle Formation. Figure 3.2-5, Site Boring Plan and Profile, depicts this stratigraphy. In some locations, the caprock (caliche) overlies sand and gravel, with the red bed clay Chinle Formation at the base of the pit. In some areas the caprock is missing and the sand and gravel is exposed at the surface. The caprock is generally fractured and following precipitation events may allow infiltration that quickly bypasses any roots from surface vegetation. In addition, gravel outcrops may allow rapid infiltration of precipitation. These conditions have led to instances of minor amounts of perched groundwater at the base of the sand and gravel unit, atop the red bed Chinle Formation. The Chinle red bed clay has a very low permeability, about 1 x 10-8 cm/s (4 x 10-9 in/s) (Rainwater, 1996), and serves as a confining unit arresting downward percolation of localized recharge flux. This shallow perched zone is not pervasive throughout the area.

Conditions at the NEF site are different than at the Wallach Concrete site. Two differences are of particular importance. First, the caprock is not present at the NEF site. Therefore, rapid infiltration through fractured caliche does not contribute to localized recharge at the NEF site. Second, the surface soils at the NEF site are finer-grained than the sand and gravel at the Wallach Concrete site. There is a thin layer of sand and gravel just above the red bed Chinle clay unit on the NEF site, but based on recent investigations, it is not saturated.

Another instance of possible saturation above the Chinle clay may be seen at Baker Spring, just to the northeast of the NEF site. Baker Spring is located at the edge of an escarpment, where the caprock ends. Baker Spring is intermittent, and water typically flows from it only after precipitation events. There may be some water seeping from the sand and gravel unit beneath the caprock and into Baker Spring. The area where Baker Spring is located is underlain by the Chinle clay. Deep infiltration of water is impeded by the low permeability of the clay. Therefore, seepage and/or precipitation/runoff into the Baker Spring area appear to be responsible for the intermittent localized flow and ponding of water in this area. Flows from this feature are intermittent, unlike those supplying the Wallach Concrete pits. This condition does not exist at the NEF site due to the absence of the caprock and the low permeability surface soils.

A recent investigation of the Baker Spring area supports the conclusion that the feature is man-made and results from the historical excavation of gravel and caprock materials that are present above the redbed clay. As a result of the excavation, Baker Spring is topographically lower than the surrounding area. Following rainfall events, ponding on the excavation floor occurs. Because the excavation floor consists of very low permeability clay of the redbed, limited vertical migration of the ponded water occurs. Shading from the high wall and trees that have flourished in the excavated area retard the natural evaporation rates and water stands in the pond for sometime. It is also suspected that during periods of ponding, surface water infiltrates into the sands at the base of the excavated wall and is retained as bank storage. As the surface water level declines, the bank storage is discharged back to the excavation floor.

A third instance of localized shallow groundwater occurrence exists to the east of the NEF site where several windmills on the WCS property were used to supply water for stock tanks. These windmills tapped small saturated lenses above the Chinle Formation red beds. The amount of groundwater in these zones is limited. The source of recharge for these localized perched zones is likely to be "buffalo wallows," (playas) depressions located near the windmills. The buffalo wallows are substantial surface depressions that collect surface water runoff. Water collecting in these depressions is inferred to infiltrate below the root zone due to the ponding conditions. WCS has drilled monitoring wells in these areas to characterize the nature and extent of the saturated conditions. Some of these wells are dry, owing to the localized nature of the perched conditions. When water is encountered in the sand and gravel above the Chinle Formation red beds, its level is slow to recover following sampling events due to the low permeability of the perched saturated zones. The discontinuity of this saturated zone and its low permeability argue against its definition as an aquifer. No buffalo wallows or related groundwater conditions occur on or near the NEF site.

The hydrologic conditions that occur in the shallow surface regime at the NEF site are substantiated by field investigations including geochemical and soil-physics based techniques, as well as computer modeling, and show that there is no recharge occurring in thick, desert vadose zones with desert vegetation (Walvoord, 2002). Precipitation that infiltrates into the subsurface is efficiently transpired by the native vegetation. Vapor-phase movement of soil-moisture may occur, but it is also intercepted by the vegetation. In a thick vadose zone, such as at the NEF site, the deeper part of that zone has a natural thermal gradient that induces upward vapor diffusion. As a result, a small flux of water vapor rises from depth to the base of the root zone, and any infiltration coming from the land surface is captured by the roots of the plants within the top several meters of the profile. Effectively, there is a maximum negative pressure potential at the base of the root zone that acts like a sink, where water is taken up by the plants and transpired. These deep desert soil systems have functioned in this manner for thousands of years, essentially since the time of the last glacial period when precipitation rates fell dramatically. It is expected that these conditions will remain for several thousand more years (until the next glacial period), unless the hydrology and vegetation is altered dramatically.

3.2.4.3 Floods

The NEF site is located above the 100 or 500-year flood elevation (WBG, 1998 and FEMA, 1978).

The NEF site is contained within the Landreth-Monument Draw Watershed. The closest water conveyance is Monument Draw, a typically dry, intermittent stream located about 4 km (2.5 mi) west of the site. The maximum historical flow for Monument Draw is 36.2 m^3/s (1,280 ft3/s) measured June 10, 1972. All other historical maximum measurements are below 2.0 m^3/s (70 ft3/s) (USGS, 2003a). Therefore, a flood is not considered to be a design basis event for the NEF site.

3.2.4.4 Groundwater Hydrology

A subsurface investigation was performed for the NEF site during September 2003 to delineate specific hydrologic conditions. Figure 3.2-5 shows the locations of these initial subsurface borings and the observation wells.

The WCS facility, located east of the site in Texas, has had numerous subsurface investigations performed for the purpose of delineating and monitoring site subsurface hydrogeologic conditions. Much of this information is directly pertinent to the NEF site. The WCS hydrogeologic data was used in planning the recent NEF site investigations. A recent evaluation of potential groundwater impacts in the area provides a good overview of the investigations performed for the WCS facility. (Rainwater, 1996)

The NEF site investigation initiated in September 2003 had two main objectives: 1) to delineate the depth to the top of the Chinle Formation red beds to assess the potential for saturated conditions above the red beds, and 2) to complete three monitoring wells in the siltstone layer beneath the red beds to monitor water level and water quality within this thin horizon of perched intermittent saturation.

Nine preliminary boreholes oriented on a three-by-three grid were drilled to the top of the Chinle Formation red beds (Figure 3.2-5). Only one of the borings produced cuttings that were slightly moist at 1.8 to 4.2 m (6 to 14 ft) below ground surface; other cuttings were very dry. Left open for at least a day, no groundwater was observed to enter any of these holes. Also, ground water was not encountered during drilling in any of the additional 59 NEF site borings, which are documented in Appendices A and C of the Geotechnical Report (NTS Report No. 114489-G-01, Rev. 00) and some of which were drilled as deep as 30.5 m (100 ft) below grade.

The land surface elevation was surveyed at each of the nine preliminary borehole locations and the elevation of the top of the Chinle Formation red beds was computed. This information was combined with similar information from the WCS facility to produce an elevation map of the top of the red beds (See Figure 3.2-5). The dry nature of the soils from each of these borings supports a conclusion that there is no recharge from the ground surface at the site (Walvoord, 2002).

The three original ground water monitoring wells were installed at the end of September 2003. (Figure 3.2-5). Through the first month of monitoring only one well, MW-2, located at the northeast corner of the site, produced water. Several samples have been taken from that well.

In 2007, fifteen additional (largely peripheral) ground water monitoring wells were drilled, and monitoring well MW-3 was plugged and abandoned because of its location in the foot print of the Storm Water Detention Basis. In 2008, eight more ground water monitoring wells were drilled adjacent to the UBC Storage Pad and UBC Storage Pad Storm Water Retention Basis. Monitoring well locations are depicted on Figure 3.2-5A.

Another factor to consider relative to hydrologic conditions at the NEF site is the presence of the Triassic Chinle Formation red bed clay. This clay unit is approximately 323 to 333 m (1,060 to 1,092 ft) thick beneath the site. With an estimated hydraulic conductivity on the order of

2.0 E-8 cm/s (7.9 E-9 in/s), the unit is very tight. This permeability is of the same order prescribed for engineered landfill liner materials. The expected vertical travel times through this clay unit would be on the order of thousands of years, based on this permeability and the thickness of the unit.

The first presence of saturated porous media beneath the site appears to be at the base of the Chinle red bed clay where there exists a low-permeability silty sandstone or siltstone. Borings and monitor wells at the WCS facility directly to the east of the NEF site have encountered this zone approximately 61 to 91 m (200 to 300 ft) below land surface. Wells completed in this unit are very slow to produce water. This makes sampling quite difficult. It is arguable whether this zone constitutes an aquifer, given the low permeability of the unit. As discussed above, the three original monitoring wells were installed on the NEF site in September 2003 with screened intervals within this siltstone unit. Approximately 73 m (240 ft) deep. There is also a 30.5-m (100-foot) water-bearing sandstone layer at about 183 m (600 ft) below ground surface.

The first occurrence of a well-defined aquifer is approximately 340 m (1,115 ft) below land surface, within the Santa Rosa formation. Because of the depth below land surface to this unit, and the fact that the thick Chinle clay unit would limit any potential migration to depth, this aquifer has not been investigated. No impacts are expected to the Santa Rosa aquifer.

Based on groundwater levels in MW-2 and data from the adjacent WCS site, a groundwater gradient of 0.011 m/m (ft/ft) was determined, generally sloping towards the south. Hydraulic conductivity of the saturated layer, based on slug tests is estimated to be approximately

3.7 E-6 cm/s (1.5 E-6 in/yr). Based on the data collected at the NEF and WCS, the groundwater gradient in the siltstone unit at NEF is estimated to range from approximately 0.011 to 0.017 m/m (0.011 to 0.017 ft/ft).

Figure 3.2-6, Water and Oil Wells in the Vicinity of the NEF Site, is a map of wells and surface water features in the vicinity of the NEF site. The figure also includes oil wells. No water wells are located within 1.6 km (1 mi) of the site boundary.

3.2.4.5 Groundwater Chemistry

As discussed in Section 3.2.4.4, water resources in the area of the NEF site are minimal. Precipitation runoff at the site is effectively collected and contained by detention/retention basins and through evapotranspiration. It is highly unlikely that any groundwater recharge will occur at the site.

The first occurrence of groundwater beneath the NEF site is in a silty sandstone or siltstone horizon in the Chinle Formation, approximately 65 to 68 m (214 to 222 ft) below the surface. This unit is low in permeability and does not yield water readily. Groundwater quality in monitoring wells in the Chinle Formation, the shallowest saturated zone, is poor due to natural conditions. Samples from monitoring wells within this horizon on the WCS facility have routinely been analyzed with Total Dissolved Solids (TDS) concentrations between about 2,880 and 6,650 mg/l. Metal analyses from four background monitoring wells at the WCS site sampled during the period 1997-2000 show that essentially all results are below maximum contaminate limits (MCL) for EPA drinking water standards. The tightness of the formation, the limited thickness of saturation, and the poor water quality, support the argument that this zone does not constitute an aquifer.

Three monitor wells MW-1, MW-2, and MW-3, were initially drilled and installed on the NEF site (as shown on Figure 3.2-5) in 2003, and several water quality samples were obtained. Subsequently, in 2007, fifteen additional (largely peripheral) ground water monitoring wells were drilled, and monitoring well MW-3 was plugged and abandoned because of its location in the foot print of the Storm Water Detention Basis. In 2008, eight more ground water monitoring wells were drilled adjacent to the UBC Storage Pad and UBC Storage Pad Storm Water Retention Basis. Monitoring well locations are depicted on Figure 3.2-5A. Water quality characteristics are similar to those for WCS site samples. A detailed discussion of the groundwater sample analysis is presented in Section 3.4.2, Water Quality Characteristics, of the Environmental Report.

3.2.5 Geology

This section identifies the geological, seismological, and geotechnical characteristics of the NEF site and its vicinity. Some areas immediately adjacent to the site have been thoroughly studied in recent years in preparation for construction of other facilities including the Waste Control Specialists (WCS) site and the former proposed Atomic Vapor Laser Isotope Separation (AVLIS) site. Data remain available from these investigations in the form of reports (WBG, 1998; TTUWRC, 2000). These documents and related materials provide a significant description of geological conditions for the NEF site. In addition, LES performed field investigations, where necessary, to confirm site-specific conditions.

3.2.5.1 Regional Geology

The site is located near the boundary between the Southern High Plains Section (Llano Estacado) of the Great Plains Province to the east and the Pecos Plains Section to the west. The boundary between the two sections is the Mescalero Escarpment, locally referred to as Mescalero Ridge. That ridge abruptly terminates at the far eastern edge of the Pecos Plains. The ridge is an irregular erosional topographic feature in southern Lea County where it exhibits relief of about 9 to 15 m (30 to 50 ft) compared with a nearly vertical cliff and relief of approximately 45 m (150 ft) in northwestern Lea County. The lower relief of the ridge in southeastern Lea County is due to partial cover by wind deposited sand (WBG, 1998). The dominant geologic feature of this region is the Permian Basin. The NEF site is located within the Central Basin Platform area. This platform occurs between the Midland and Delaware Basins, which comprises the Permian Basin. The basin, a 250 million-year-old feature, is the source of the region's prolific oil and gas reserves. The late Cretaceous to the early Tertiary (65 to 70 million years ago) marked the beginning of the Laramide Orogeny, which formed the Cordilleran Range to the west of the Permian Basin. That orogeny uplifted the region to its present elevation.

The primary difference between the Pecos Plains and the Southern High Plains physiographic sections is a change in topography. The High Plains is a large flat mesa which uniformly slopes to the southeast. In contrast, the Pecos Plains Section is characterized by its more irregular erosional topographic expression (WBG, 1998).

The Permian Basin, a massive subsurface bedrock structure, is a downward flexure of a large thickness of originally flat-lying, bedded, sedimentary rock. It dominates the geologic structure of the region. It extends to 4,880 m (16,000 ft) below msl. The NEF site is located above the Central Basin Platform that divides the Permian Basin into the Midland and Delaware sub-basins. The base of the Permian basin sediments extend about 1,525 m (5,000 ft) deep beneath the NEF site.

The top of the Permian deposits is approximately 434 m (1,425 ft) below ground surface. Overlying the Permian are the sedimentary rocks of the Triassic Age Dockum Group. The upper formation of the Dockum Group is the Chinle. Locally, the Chinle Formation consists of red, purple and greenish micaceous claystone and siltstone with interbedded fine-grained sandstone. The Chinle is regionally extensive with outcrops as far away as the Grand Canyon region in Arizona (WBG, 1998). Locally overlying the Chinle Formation in the Permian Basin is either the Tertiary Ogallala, Gatuña or Antlers Formations, or Quaternary alluvium. The Tertiary Ogallala Formation underlies all of the High Plains (to the east) and mantles several ridges in Lea County. Unconsolidated sediments northeast of the NEF site are recognized as the Ogallala and deposits west of the NEF site are mapped as the Gatuna or Antlers Formations. This sediment is described as alluvium (WBG, 1998) and is mined as sand and gravel in the NEF site.

The Chinle Formation is predominately red to purple moderately indurated claystone, which is highly impermeable (WBG, 1998). Red Bed Ridge is a significant topographic feature in this regional plain that is just north and northeast of the NEF site, and is capped by relatively resistant caliche. Ground surface elevation increases about 15 m (50 ft) from +1,045 m (+3,430 ft) to +1,059 m (+3,475 ft) across the ridge.

Recent deposits at the site and in the site area are primarily dune sands derived from Permian and Triassic rocks of the Permian Basin. The so-called Mescalero Sands cover approximately 80% of Lea County, locally as active sand dunes.

Two types of faulting were associated with early Permian deformation. Most of the faults were long, high-angle reverse faults with well over a hundred meters (several hundred feet) of vertical displacement that often involved the Precambrian basement rocks. The second type of faulting is found along the western margin of the platform where long strike-slip faults, with large displacements, are found. The nearest recent faulting to the site is defined by the New Mexico Bureau of Geology and Mineral Resources (NMIMT, 2003) and is over 161 km (100 mi) to the west associated with the deeper portions of the Permian Basin (Machette, 1998).

The large structural features of the Permian Basin are reflected only indirectly in the Mesozoic and Cenozoic rocks, as there has been virtually no tectonic movement within the basin since the Permian period. Figure 3.2-7, Permian Basin Geologic Structures and Profile, shows the structure that causes the draping of the Permian sediments over the Central Basin Platform structure, located approximately 2,134 m (7,000 ft) beneath the present land surface. The faults that uplifted the platform do not appear to displace the younger Permian sediments.

The Southeast New Mexico-West Texas area presently is structurally stable. The Permian Basin has subsided slightly since the Laramide Orogeny. This is believed to be a result of dissolution of the Permian evaporite layers by groundwater infiltration and possible from oil and gas extraction (WBG, 1998).

3.2.5.2 Site Geology

Topographic relief on the site is generally subdued. NEF site elevations range between about +1,030 and +1,053 m (+3,380 and +3,455 ft), mean sea level (msl) (See Figure 3.2-8, Site Topography). Finished site grade will range about +1,041 m (+3,415 ft), msl. The NEF site itself encompasses 220 ha (543 acres), of which 73 ha (180 acres) will be developed. Small-scale topographic features within the boundary of the proposed NEF site include a closed depression evident at the northern center of the site, the result of eolian processes, and a topographic high at the southwest corner of the site is created by dune sand. In general the site slopes from northeast to southwest with a general overall slope of about 0.5%. Red Bed Ridge (TTUWRC, 2000) is an escarpment of about 15 m (50 ft) in height that occurs just north and northeast of the NEF site. Geologically the site is located in an area where surface exposures consist mainly of Quaternary-aged eolian and piedmont sediments along the far eastern margin of the Pecos River Valley (NMIMT, 2003). Figure 3.2-9, Surficial Geologic Map of the NEF Site Area, is a portion of the Surficial Geologic Map of Southeast New Mexico (NMIMT, 1977), which includes the area of the NEF site. The surficial unit shown on this map at the NEF site is described as a sandy alluvium with subordinate amounts of gravel, silt and clay. Figure 3.2-9 also shows other surficial units in the site vicinity including caliche, a partly indurated zone of calcium carbonate accumulation formed in the upper layers of surficial deposits including tough slabby surface layers and subsurface nodules, fibers and veinlets; loose sand deposits, some gypsiferous, and subject to wind erosion. Other surficial deposits in the site area include floodplain channel deposits along dry channels and playa sands.

Recent deposits of dune sands are derived from Permian and Triassic rocks. These so-called Mescalero Sands (also known as the Blackwater Draw Formation) occur over 80% of Lea County and are generally described as fine to medium-grained and reddish brown in color. The USDA Soil Survey of Lea County identifies the dune sands at the site as the Brownsfield-Springer Association of reddish brown fine to loamy fine sands (USDA, 1974).

Figure 3.2-5 includes the preliminary NEF site and adjacent site original borings and a geologic profile from the immediately adjacent parcel to the east that provides a representation of site geology. The profile shows alluvial deposits about 9 to 15 m (30 to 60 ft) thick, cemented by soft caliche layer 1 to 4 m (3 to 12 ft) that occurs at the top of the alluvium. Locally on the site dune sand overlies both these deposits. The alluvium rests on the red beds of the Chinle Formation, a silty clay with lenses of sandy clay or claystone and siltstone. Information from recent borings done on the NEF site is consistent with the data shown on Figure 3.2-5. Borings on the NEF site depicted on Figure 3.2-5 include:

- Three borings/monitoring wells (MW-1, MW2, and MW-3)
- Nine site groundwater exploration borings (B-1 through B-9)
- Five geotechnical borings (B-1 through B-5).

Other borings depicted on Figure 3.2-5, not on the NEF site, were performed by others. In 2007, fifteen additional ground water monitoring wells wer drilled at locations depicted on Figure 3.2-5A, and monitoring well MW-3 was plugged and abandoned because of its location in the footprint of the Storm Water Detention Basin.

In 2007, fifteen additional (largely peripheral) ground water monitoring wells were drilled, and monitoring well MW-3 was plugged and abandoned because of its location in the foot print of the Storm Water Detention Basis. In 2008, eight more ground water monitoring wells were drilled adjacent to the UBC Storage Pad and UBC Storage Pad Storm Water Retention Basis. Monitoring well locations are depicted on Figure 3.2-5A.

The preliminary NEF site original boring test records are shown on Figures 3.2-10 through 3.2-14. A key to the symbols and descriptions shown on the test records is provided in Figure 3.2-15, Soil Test Boring Key to Symbols and Descriptions.

The NEF site lies within the Landreth-Monument Draws Watershed. Site drainage is to the southwest with runoff not able to reach any water body before it evaporates. The only major regional drainage feature is Monument Draw, which is located just over 4 km (2.5 mi) west of the site, between the proposed NEF site and the city of Eunice, New Mexico (USDA, 1974). The draw begins with a southeasterly course to a point north of Eunice where it turns south and becomes a well defined cut approximately 9 m (30 ft) in depth and 550 to 610 m (1,800 to 2,000 ft) in width. The draw does not have through-going drainage and is partially filled with dune sand and alluvium.

Along Red Bed Ridge (TTUWRC, 2000), approximately 1.6 km (1.0 mi) northeast of the NEF site, is Baker Spring. The depression formed by Baker Spring contains water only intermittently.

No significant non-petroleum mineral deposits are known to exist in the vicinity of the NEF site. The surface cover of silty sand and gravel overlies a claystone of no economic value. No mineral operations are noted in Lea County by the New Mexico Bureau of Mines Inspection (NMBMI, 2001). Mining and potential mining of potash, a commonly extracted mineral in New Mexico, is followed by the New Mexico Energy, Minerals and Natural Resources Department, which maintains a map of areas with potash mines and mining potential (NMEMNRD, 2003). Those data indicate neither mining nor potential for mining of potash in the NEF site area.

The topographic quadrangle map that contains the site (USGS, 1979) contains 10 locations where sand and gravel have been mined from surface deposits, spread across the quadrangle, over an area about 12 by 14 km (7.5 by 8.9 mi), suggesting that suitable surficial deposits for borrow material are widespread.

Exploratory drill holes for oil and gas are absent from the site area and its vicinity, but are common 8 km (5 mi) west in and around the city of Eunice, New Mexico. That distribution, and the time period of exploration since the inception of exploration for this area, suggests that the potential for productive oil drilling at the NEF site is not significant.

Soil development in the region is generally limited due to its semi-arid climate. The site has a minor thickness of silty soil (generally less than 0.4 m (1.4 ft)) developed from subaerial weathering. Caliche deposits are common in the near-surface soils. A small deposit of active dune sand is present at the southwest corner of the site.

The U. S. Department of Agriculture soil survey for Lea County, New Mexico (USDA, 1974) categorizes site soils as hummocky loamy (silty) fine sand with moderately rapid permeability and slow runoff, well-drained non-calcareous loose sand, active dune sand and dune-associated sands. Near-surface caliche deposits may locally limit (limiting soil porosity) or enhance (fractured caliche) surface drainage. Detailed information about soil composition across the NEF site can be found in Appendices A and C of the Geotechnical Report (NTS Report No. 114489-G-01, Rev. 00).

3.2.5.3 Geotechnical Investigations

Previously completed geotechnical investigations on property near the site provide the following subsurface information. Based on the data from those investigations, subsurface conditions are described as follows. Topsoil occurs as 0.3 m (1 ft) or less of brown organic silty sand that overlies a formation of white or tan caliche. The caliche consists of very hard to friable cemented sand, conglomerate limestone rock, silty sand and gravel. A sand and gravel layer varying from 0 to 6 m (0 to 20 ft) in thickness occurs at the bottom of the caliche strata. Below the caliche is a reddish brown silt clay that extends to the termination of the preliminary borings, 30 to 91 m (100 to 300 ft) below grade. The red beds consist of a highly consolidated, impervious clay:

- mottled reddish brown-gray clay
- purple-gray silty clay and
- yellowish brown-gray silty clay
- siltstones and sandstone layers found at various depths with varying thicknesses.

The depth to the top of the red beds in preliminary borings done for engineering purposes ranged from about 3.6 to 9.1 m (12 to 30 ft).

The measured permeabilities for the reddish brown silty clays, sandstones and siltstones indicate the clay is highly impervious. The siltstones are slightly more permeable but still have relatively low permeability.

Unconfined compressive tests on the clay during the September 2003 geotechnical investigation resulted in values of 136,000 kg/m^2 to 485,000 kg/m^2 (13.9 to 49.7 tons/ft^2) with an average value of 293,000 kg/m^2 (30 tons/ft^2).

Detailed information about soil composition across the NEF site, including N-values, can be found in Appendices A and C of the Geotechnical Report (NTS Report No. 114489-G-01, Rev. 00). Allowable bearing pressures can be found in Table 5.8-2 and Figures 5.8-1 and 5.8-2 of the Geotechnical Report, and these values are based on the assumptions in Section 5.8 of the report. The California Bearing Ratio (CBR) test results can be found in Section 5.6.1 of the report. Table 5.9-4 of the report gives maximum dry density values. A discussion of the soil's Young's modulus and a plot of the soil's Young's modulus can be found in Section 5.9.3 and Figure 5.9-4 of the report, respectively. Information on Atterburg limits can be found in Table 2-2 and Figure 2-5 of the report. A graph of the percentage of soil particles passing No. 200 sieve size vs. elevation is given in Figure 2-3 of the report. Table 2-3 of the report gives information about moisture content.

3.2.6 Seismology

The majority of earthquakes in the United States are located in the tectonically active western portion of the country. However, areas within New Mexico and the southwestern United States also experiences earthquakes, although at a lower rate and at lower intensities. Earthquakes in the region around the NEF site are isolated or occur in small clusters of low to moderate size events toward the Rio Grande Valley of New Mexico and in Texas, southeast of the NEF site.

3.2.6.1 Seismic History of the Region and Vicinity

The NEF site is located within the Permian Basin as shown on Figure 3.2-17, Tectonic Subdivisions of the Permian Basin (Talley, 1997). Specifically, the site is located near the northern end of the Central Basin Platform (CBP). The CBP became a distinct dividing feature within the Permian Basin as a result of Pennsylvanian and early Permian compressional stresses. This tectonism resulted in a deeper Delaware Basin to the west and shallower Midland Basin to the east of the ridge-like CBP.

The last episode of tectonic activity centered on the late Cretaceous and early Tertiary Laramide Orogeny that formed the Cordilleran Range to the west of the Permian Basin. The Permian Basin region was uplifted to its present position during this orogenic event. There has not been any further tectonic activity since the early Tertiary. Structurally, the Permian Basin has subsided slightly since the Larmaide tectonic event. Dissolution of Permian evaporate layers by groundwater infiltration or possibly from oil and gas extraction is suggested as a possible cause for this observed subsidence.

The 250 million year old Permian Basin is the source of abundant gas and oil reserves that continue to be extracted. These oil fields in southeast New Mexico are characterized as "in mature stage of secondary recovery effort" (Talley, 1997). Water flooding began in the late 1970's followed by CO2 flooding now being used to enhance recovery in some fields. Industry case studies describe hydraulic fracturing procedures used in the Queen and San Andres formations near the NEF site that produced fracture half-lengths from 170 to 259 m (560 to 850 ft) in these formations.

Locations of recent tectonic faulting within the 322 km (200 mi) radius of the NEF site located in Lea County, New Mexico, were determined through literature research (DOE, 2003; Machette, 1998; Machette, 2000; USGS, 2004). No Quaternary faults are mapped for the site locale. The nearest recent faulting is situated more than 161 km (100 mi) west of the site (Machette, 1998). Figure 3.2-33, Quaternary Faults in New Mexico, and Figure 3.2-34, Quaternary Faults in Texas, illustrate traces of Quaternary Faults for New Mexico and adjacent areas of west Texas. The Quaternary geologic time period extends from 1.6 million years ago to the present. Other time sub-divisions within the Quaternary include the Late Quaternary that extends from 130,000 years ago to the present, and the Holocene, which includes the most recent 10,000-year time period.

Shown on Figures 3.2-33 and 3.2-34 are 1° Latitude by 2° Longitude geographic blocks. The NEF site is located in the Hobbs geographic block. Geographic blocks containing Quaternary faults are color-coded (i.e., non-gray). Figure 3.2-35, Quaternary Faults Within 322 km (200 mi) of NEF Site, shows geographic blocks for which Quaternary faults are mapped. All of these geographic blocks are located west of the NEF site. Figure 3.2-36, Locations of Nearest Faults to the NEF Site, shows the Quaternary fault locations detailed in the "Map and data for Quaternary faults and folds in New Mexico, U.S. Geological Survey (USGS) Open-File Report 98-521" (Machette, 2000). The block containing the site, as well as others due north, south, and east of the NEF site has no documented Quaternary faults. Quaternary faults within 322 km (200 mi) of the site are shown on Figure 3.2-35 using colored and numbered traces, and are plotted over shaded relief topographic maps. The use of topographic relief maps is highly illustrative, because ground deformations resulting from recent fault movements are usually manifested as prominent linear topographic features.

Figure 3.2-36 provides a summary of Quaternary fault locations, including fault names obtained from the "Map and data for Quaternary faults and folds in New Mexico, USGS Open-File Report 98-521" (Machette, 2000) and the "Earthquake Hazards Program, Quaternary Fault and Fold Database of the United States" (USGS, 2004).

Quaternary-Aged Faults designated as capable within 322 km (200 mi) of the NEF site include the West Delaware Mountain Fault Zone, the Guadalupe Fault, the East Sierra Diablo Fault, the East Flat Top Mountain Fault and the Alamogordo Fault at 185 km (115 mi), 191 km (119 mi), 196 km (122 mi), 200 km (124 mi) and 262 km (163 mi) from the site, respectively. In addition, the East Baylor Mountain – Carrizo Mountain Fault is located 201 km (125 mi) from the NEF and is considered a possible, capable fault, but movement within the last 35,000 years has not been demonstrated.

None of the capable faults pose a ground deformation hazard to the NEF site due to the distances (> 161 km (100 mi)) from the site, the northerly strike of these faults and the associated topographic landforms shown in Figure 3.2-36, Location of Nearest Faults to the NEF Site. The strikes of the assessed capable faults do not project toward the NEF site. Topographic features, like those correlated to the Quaternary faults west of the site, are not present near the NEF site, thus making it an unlikely scenario that unmapped, capable faults are located nearer than 161 km (100 mi) to the NEF site.

The study of historical seismicity includes earthquakes in the region of interest known from felt or damage records and from more recent instrumental records (since early 1960's). Most earthquakes in the region have left no observable surface fault rupture.

Figure 3.2-18, Seismicity Map for 200-Mile Radius of the NEF Site, indicates the location of earthquakes which have occurred within a 322 km (200 mi) radius of the NEF site with magnitude > 0. The earthquakes are also listed in Table 3.2-20, Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site. Figure 3.2-19, Seismicity in the Immediate Vicinity of the NEF Site, indicates the location of earthquakes within about 97 km (60 mi) of the NEF site. Earthquakes, which have occurred within a 322 km (200 mi) radius of the NEF site with a magnitude of 3.0 and greater, are listed in Table 3.2-21, Earthquakes of Magnitude 3.0 and Greater Within 322 km (200 mi) Radius of the NEF Site.

The data reflected in the above figures and tables are from earthquake catalogs from the University of Texas Institute for Geophysics (UTIG, 2002), New Mexico Tech Historical Catalog (NMIMT, 2002), Advanced National Seismic System (USGS, 2003b) and the New Mexico Technical Regional Catalog, exclusive of Socorro New Mexico events (NMIMT, 2002).

Earthquake data for a 322 km (200 mi) radius of the NEF site were acquired from public domain resources. Table 3.2-22, Earthquake Data Sources for New Mexico and West Texas, lists organizations and data sources that were identified and earthquake catalogs that were obtained.

Earthquake parameters (e.g., date, time, location coordinates, magnitudes, etc.) from the data repositories listed in Table 3.2-22 were combined into a uniformly formatted database to allow statistical analyses and map display of the four catalogs. Through a process of comparison of earthquake entries among the four catalogs, duplicate events were purged to achieve a composite catalog. In addition, aftershocks and aftershock sequences were purged from one version of the catalog for computation of earthquake recurrence statistical models, which describe recurrence rates of earthquake main shocks. The composite list of earthquakes, with aftershock and aftershock sequences purged, for the 322 km (200 mi) radius of the NEF site is provided in Table 3.2-20. The regional seismicity map is shown on Figure 3.2-18. Local seismicity is shown on Figure 3.2-19, Seismicity in the Immediate Vicinity of the NEF Site. The large majority of events (i.e., 82%) in the composite catalog originate from the Earthquake Catalogs for New Mexico (exclusive of the Socorro New Mexico immediate area) (NMIMT, 2002) as observed in the event counts in Table 3.2-22. Earthquake magnitudes in these catalogs (NMIMT, 2002) are tied to the New Mexico duration magnitude scale, Md, that in turn approximate Local Magnitude, ML. All events in the composite catalog are specified to have an undifferentiated local magnitude.

Table 3.2-21 shows all earthquake main shocks of magnitude 3.0 and larger within a 322 km (200 mi) radius of the NEF site. The largest earthquake within 322 km (200 mi) of the NEF is the August 16, 1931 earthquake located near Valentine, Texas. This earthquake has an estimated magnitude of 6.0 to 6.4 and produced a maximum epicentral intensity of VIII on the Modified Mercalli Intensity (MMI) Scale. The intensity observed at the NEF site is IV on the MMI scale (NMGS, 1976). A copy of the MMI scale is provided in Table 3.2-23, Modified Mercalli Intensity Scale.

The closest of these moderate earthquakes occurred about 16 km (10 mi) southwest of the site on January 2, 1992.

It is noted that the University of Texas Geophysics Institute Catalog of West Texas Earthquakes reports a smaller magnitude of 4.6 and a more easterly epicenter location in Texas.

Table 3.2-24, Comparison of Parameters for the January 2, 1992 Eunice, New Mexico Earthquake, shows the location and size parameters for the Earthquake. Parameters given by New Mexico Tech Regional Catalog were adopted for the seismic hazard assessment of the NEF site.

3.2.6.2 Correlation of Seismicity with Tectonic Features

Earthquake epicenters scaled to magnitude for the site region are plotted over Permian Basin tectonic elements on Figure 3.2-20, Regional Seismicity and Tectonic Elements of the Permian Basin. Most epicenters lie within the Central Basin Platform, however, earthquake clusters also occur within the Delaware and Midland Basins. Although events local to the NEF site are likely induced by gas/oil recovery methods, the resulting ground motions are transmitted similar to earthquakes on tectonic faults and impacts at the NEF site are analyzed using standard seismic hazard methods. Furthermore, given the published uncertainties on discrimination between natural and induced seismic events and that earthquake focal depths, critical for correlation with oil/gas reservoirs, are largely unavailable, the January 2, 1992 event is attributed to a tectonic origin. For this magnitude 5 earthquake, focal depths range from 5 km (3.1 mi) (USGS, 2004) to 12 km (7.5 mi) (DOE, 2003). Therefore, studies conclude that seismological data are insufficient for this moderate earthquake to constrain the depth sufficiently to permit a correlation with local oil/gas producing horizons.

Analysis of the spatial density of earthquakes in the composite catalog is shown on Figure 3.2 21, Earthquake Frequency Contours and Tectonic Elements of the Permian Basin. This form of spatial analysis has historically been used to define the geometry of seismic source zones for seismic hazard investigations (USGS, 1997; USGS, 1976a). Seismic source areas for the NEF site region are determined on the basis of the earthquake frequency pattern shown on Figure 3.2-22, Seismic Source Areas for Earthquake Frequency Statistical Analyses. The NEF site is located near the northern end of the region of highest observed earthquake frequency within the CBP of the Permian Basin.

The Waste Isolation Pilot Plant (WIPP) Safety Analysis Report (SAR) (DOE, 2003) suggests that the cluster of small events located along the CBP (Figure 3.2-20) are not tectonic in origin, but are instead related to water injection and withdrawal for secondary recovery operations in oil fields in the CBP area. Such a mechanism for the CBP seismic activity could provide a reason why the CBP is separable from the rest of the Permian Basin on the basis of seismicity data but not by using other common indicators of tectonic character. Both the spatial and temporal association of CBP seismicity with secondary recovery projects at oil fields in the area are suggestive of some cause and effect relationship of this type.

3.2.6.3 Earthquake Recurrence Models

Earthquake recurrence models describe the exponential frequency versus magnitude behavior observed for earthquake activity (Gutenberg, 1944). The exponential recurrence model is commonly shown as Equation [3.2-1].

$$\text{Log}_{10} N_C = a + b(M) \qquad \text{[Eq. 3.2-1]}$$

Where: N_C = cumulative number per time duration (i.e., per year)

a = a-value, indicator of activity rate

$b(M)$ = b-value, with negative slope due to observation that smaller magnitude events occur more frequently than larger magnitude events. Typical range of b-values is -0.5 to -1.5, normally closer to -1.0.

Earthquake recurrence models were computed for the entire 322 km (200 mi) radius composite catalog and for two smaller regions. The smaller regions are defined by patterns of seismic activity as noted at closer distances to the site. Region 1 shown on Figure 3.2-22 includes clusters of earthquakes within an approximate 161 km (100 mi) radius of the site. The second sub-region includes the high-density earthquake pattern observed in the CBP. A tectonic origin for all events in the CBP was conservatively assumed.

Results of statistical analyses performed on the 322 km (200 mi) composite catalog and two sub-regions are illustrated on Figures 3.2-23 through 3.2-25. Best fit models and models for which the b-value is constrained to a value of -0.9 were computed. These models are numerically compared in Table 3.2-25, Earthquake Recurrence Models for the NEF Site Region.

Earthquake recurrence models provided in the WIPP SAR (DOE, 2003) for more distant seismic zones including the two Rio Grande Rift source zone alternatives (see Figure 3.2-26, Alternate Seismic Source Geometries Used in the WIPP Seismic Hazard Study) were used in the hazard assessment of the NEF site. Recurrence models from the WIPP SAR (DOE, 2003) are shown in Table 3.2-32, Horizontal Response Spectrum for the 10,000-Year and Design Basis Earthquakes. Preparers of the WIPP SAR (DOE, 2003) expressed an opinion that magnitudes in the available earthquake catalog (pre-1983) were underestimated. Therefore, two models were used to address this magnitude scaling issue. The model for corrected magnitude raised the a-value in the recurrence models by 0.5 units. Both the magnitude-corrected and uncorrected recurrence models are listed in Table 3.2-26, Earthquake Recurrence Models for the CBP in the WIPP SAR.

3.2.6.4 Probabilistic Seismic Hazard Analysis

3.2.6.4.1 Ground Motion Attenuation Models

A site-specific probabilistic seismic hazard analysis was performed for the NEF site using the seismic source zone geometries shown on Figures 3.2-22 and 3.2-26 and earthquake recurrence models listed in Tables 3.2-25 and 3.2-26. Seismic hazard computations were performed using the EQRISK computer program (Cornell, 1968; USGS, 1976b).

In addition to seismic source zones and earthquake recurrence models, computations of probabilistic seismic hazard require ground motion attenuation models suited for the regional and local seismic wave transmission characteristics. Two attenuation models were used in the analysis. The WIPP SAR (DOE, 2003) selected an attenuation model developed by O.W. Nuttli (US Army WES, 1973) for application in the central United States. This model was selected due to the precedence of its usage in the WIPP SAR seismic hazard assessment, and to its conservative predictions compared to other published models. This ground acceleration model is given in Equation 3.2-2.

$$Ln(a) = 2.833 + 0.92(M_L) - 1.0(Ln(R)) \qquad \text{[Eq. 3.2-2]}$$

Where: a = horizontal ground acceleration in cm/s2 units

M_L = Local Magnitude

R = distance from the earthquake focus to the site

Sensitivity to the attenuation model was studied by calculating seismic hazard curves for an attenuation model that approximates the Toro peak ground acceleration model (Toro, 1997). This model is provided in Equation 3.2-3 and is illustrated on Figure 3.2-27, Comparison of PGA Attenuation for a Magnitude 5.0 Earthquake.

$$Ln(a) = 2.80 + 0.92(M_L) - 1.05(Ln(R)) - 0.003(R) \qquad \text{[Eq. 3.2-3]}$$

Where: a = horizontal ground acceleration in cm/s2 units

M_L = Local Magnitude

R = distance from the earthquake focus to the site

It is noted that the Toro attenuation model provides coefficients for magnitudes scaled to the Lg-phase, mbLg, and for Moment magnitude, MO. Due to the magnitude scaling of events in the composite catalog, the moment magnitude scaling is preferred to Lg magnitude scaling for the Toro model. In addition, the Toro model has a more sophisticated functional form that flattens the PGA predictions at distances less than 10 km (6.2 mi).

In addition, probabilistic response spectra (i.e. uniform hazard response spectra) are computed for the NEF site using the Nuttli spectral attenuation models (Nuttli, 1986) listed in Table 3.2-27, Attenuation Model Formulas and Coefficients. The Nuttli spectral velocity attenuation models are considered to predict ground motions at "firm rock" conditions, which is the rock condition attributed to the Triassic Age claystones underlying the NEF site. For comparative purposes, the Nuttli (Nuttli, 1986), Toro (Toro, 1997) and WIPP SAR Nuttli (US Army WES, 1973) attenuation models are plotted on Figure 3.2-21 along with the McGuire (EPRINP-6074) attenuation model and the approximation of the Toro attenuation models.

3.2.6.4.2 Probabilistic Seismic Hazard Results

Total seismic ground motion hazard to a site results from summation of ground motion effects from all distant and local seismically active areas. The contribution to total hazard at the NEF site from more distant seismic activity in the Rio Grande Rift zones is examined first. As noted above, seismic source zone geometries (Figure 3.2-26) and recurrence rates (Table 3.2-26) were taken directly from the WIPP SAR (DOE, 2003). Recurrence rates for the magnitude corrected, and magnitude uncorrected recurrence models were used in the hazard calculations. This recurrence model variation coupled with two seismic source zone geometries results in four seismic hazard curves. In addition, maximum magnitudes of 7.8 for the Rio Grande Rift (DOE, 2003) were used for this hazard calculation. Peak ground acceleration seismic hazard results at the NEF site from the Rio Grande Rift source zone alternatives are listed in Table 3.2-28, Seismic Hazard Results at NEF Site From Rio Grande Rift Seismic Source Zones. These hazard results are plotted on Figure 3.2-28, Seismic Hazard at the NEF Site From Rio Grande Rift Seismic Sources. Seismic hazard curves shown on Figure 3.2-28 are annotated to identify the 250-year, 475-year and 10,000-year earthquake levels. It is noted that the 475-year event in most cases is strictly defined as the event with a 10% probability of being exceeded in 50 years. Strict maintenance of this probability in 50-years equates to an annual probability of 0.0021 of exceeding a 0.10 g peak horizontal acceleration and a return period of 475-years.

Seismic hazard results for the NEF site due to seismic activity in local seismic zones (i.e. seismic zones that contain the site) are listed in Table 3.2-29, Seismic Hazard Results at NEF Site From Local Source Zones. Seismic hazard curves are plotted on Figure 3.2-29, Seismic Hazard at the NEF Site From Local Seismic Zone Sources. Local seismic zones include those geometries shown on Figure 3.2-22. The largest zone includes the 322 km (200 mi) radius of the NEF site for which earthquake data were assembled. The largest earthquake contained in this 322 km (200 mi) zone is the 1931 Valentine, Texas, event with an estimated magnitude of 6.0 to 6.4. Alternative maximum magnitudes, MX, of 6.5 and 6.0 are assigned to this 322 km (200 mi) region for seismic hazard computations.

The alternative local seismic source zone geometry is defined within a more limited site radius of 161 km (100 mi). Embedded within this 161 km (100 mi) zone is the sub-region defined by the enhanced density of earthquake epicenters centered on the CBP (see Figure 3.2-21 and Figure 3.2-22). The maximum historical earthquake within these zones is the January 2, 1992, earthquake. A maximum magnitude of 6.0 is used for computation of seismic hazard curves. An identical maximum magnitude of 6.0 was specified in the WIPP SAR (DOE, 2003) for its CBP seismic source zone alternatives. In addition, the WIPP study used a smaller maximum magnitude of 5.0 in their hazard analysis due to the lack of recent geologic evidence of tectonism and likely association of events with secondary oil/gas recovery efforts in this area. Sensitivity to the maximum magnitude parameter is examined by computing seismic hazard curves for MX set to 6.0 as well as to 5.25 for the 161 km (100 mi) zone and the CBP embedded zone. Seismic hazard results shown in Table 3.2-29 and on Figure 3.2-29, illustrate the various sensitivities to choices of seismic source zones, attenuation models and maximum magnitudes, MX.

Figure 3.2-30, Zoom of Seismic Hazard at the NEF Site From Local Seismic Zone Sources, provides a zoomed-in view of the calculated seismic hazard curves for the NEF site.

Table 3.2-30, Peak Acceleration Seismic Hazard Summary for the NEF Site, provides an interpretation of these hazard curves for the 250-year and 475-year earthquake levels.

Total seismic ground motion hazard to a site results from summation of ground motion effects from all distant and local seismically active areas. A total of 12 seismic hazard curves were developed for a combination of various source zones, attenuation models, b-values and upper bound magnitudes. For the purpose of selecting the characteristic peak ground acceleration associated with specific return periods, a resultant seismic hazard curve was developed through a weighted average of the individual curves. The seismic hazard curves and weighted average hazard result are shown in Figure 3.2-29 and Figure 3.2-30.

The 250-year and 475-year return period peak horizontal ground accelerations are estimated at 0.024 g and 0.036 g, respectively (Weston, 2003). The 10,000-year return period peak horizontal ground acceleration is estimated at 0.15 g. This return period is equivalent to a mean annual probability of 1.0 E-4.

Since it is currently not possible to definitively differentiate natural tectonic from induced seismic events in the study region, the probabilistic seismic hazard estimates for the NEF site assumed a tectonic origin for all events in the CBP sub-region. However, for cases of uncertainty, sensitivity analyses provide valuable insights into the impacts of induced earthquakes on the seismic hazard analysis. The following sensitivity analysis results are provided to show trends in seismic hazard results for assumptions that increasing percentages of earthquakes in the CPB seismic source zone are induced by oil/gas recovery activities.

Two hypotheses are considered in the seismic hazard sensitivity analyses. First is the case that a fraction of earthquakes of all magnitudes are induced. Second is the case that only smaller magnitude earthquakes (e.g., less than M=3.5) are likely induced while larger events result from tectonic processes. For the first case, the hypothesis is that a large fraction of events in the CBP was induced by oil/gas recovery efforts, is modeled by scaling the CBP recurrence model by factors of 0.15, 0.5, and 0.85. These scaling factors are applied to the entire recurrence model such that the predicted frequencies of events for all magnitudes are scaled by these factors. The three scaling factors are used to model the general commentary that a "large fraction" of CPB events are induced. For the second case, the concept that many of the small events could be induced while larger events have tectonic origins is modeled by re-computation of the recurrence model for the CPB following removal of 50% of events with magnitudes less than 3.5. This second case results in a recurrence model that predicts relatively fewer small magnitude events, and recurrence rate of larger events of magnitude 5.0 and greater remains unchanged.

Seismic hazard sensitivity results only show a significant impact when a scaling factor of 0.15 is applied to the total recurrence model. For this case, peak horizontal acceleration is reduced from about 0.15 g to about 0.10 g at 1.0 E-4 annual exceedance probability. Application of a scaling factor of 0.50 to the entire model resulted in a peak horizontal acceleration near 0.13 g at 1.0 E-4 annual exceedance probability. Two of the cases, scaling the entire recurrence model by 0.85, and determination of a new model based on removal of 50% of events smaller than M=3.5, showed little sensitivity. Given uncertainties related to the tectonic vs. induced nature of larger regional events, and high likelihood that many smaller events are induced by ongoing oil/gas recovery activities, results of the last sensitivity analysis (e.g. removal of smaller events only) are preferred. The negligible sensitivity to removal of smaller events emphasizes that seismic hazard in large part is determined by the assessed regional frequency of events with magnitudes larger than 5.0.

3.2.6.4.3 Uniform Hazard Response Spectra

Probabilistic ground motion response spectra are derived for the NEF site using a combination of the Nuttli spectral attenuation model (Nuttli, 1986) and appropriate soil amplification factors currently used in Seismic Building Code applications. The Nuttli spectral velocity attenuation models are considered to predict ground motions at "firm rock" conditions, which is the rock condition attributed to the Triassic Age claystones underlying the NEF site. Descriptive characterization of the site surficial material composition and thickness supports a site soil classification of C. This site class (Dobry, 2000) accommodates gravelly soils underlain by soft rocks, which appear to be present at the site. Soil amplification factors for Site Class C include:

For $S_s < 0.25$; short period site amplification factor, $F_a = 1.2$

For $S_l < 0.10$; long period site amplification factor, $F_v = 1.7$

Where Ss and Sl are short and long period rock acceleration levels, respectively.

Horizontal component bedrock and ground surface response spectra (five percent damping ratio) for soil profile type C for the 10,000-year earthquake are plotted on Figure 3.2-31, Horizontal Response Spectra for the 10,000-Year Earthquake, Bedrock and Soil Class C for the NEF Site. By definition of their calculation, these response spectra have an equal probability of 0.005% of being exceeded in 50 years at each period in the range of 0.02 to 2.0 s.

Horizontal and vertical component uniform hazard response spectra (five percent damping) for the 10,000-year earthquake at ground surface for Soil Class C are plotted on Figure 3.2-32a. Vertical component earthquake response spectra are taken to be a factor of 2/3 times the horizontal component for all frequencies in accordance with ASCE 43-05 and ASCE 4-98. The 2/3 ratio has been selected since the design earthquake is controlled by distant seismic events.

Numerical values for the 10,000-year and design basis earthquake design response spectra for five and ten percent damping are listed in Table 3.2-32, Horizontal Response Spectrum for the 10,000-Year and Design Basis Earthquake, and Table 3.2-33, Vertical Response Spectrum for the 10,000-Year and Design Basis Earthquake, respectively.

3.2.6.5 Selection of the Design Basis Earthquake

While conducting the Integrated Safety Analysis (ISA), an unmitigated accident due to a seismic event was assumed to result in high public consequences. Therefore, the likelihood of the event (seismically-induced high public consequences) needs to be "highly unlikely". In accordance with NUREG-1520 for the NEF this equates to a probability of occurrence of less than 1.0 E-5 per year.

To define the design basis earthquake (DBE), information from DOE Standard DOE-STD-1020-2002 and ASCE Standard 43-05 were considered along with the results of the seismic portion of the ISA and the site-specific probabilistic seismic hazard analysis for the NEF site.

The DOE and ASCI approaches each outline a methodology to demonstrate compliance to a target performance goal of 1.0 E-5 annual probability. The ASCE approach was selected to develop the design basis earthquake for the NEF. The approach is based on achieving the following two goals.

- Less than about 1% probability of unacceptable performance for the DBE ground motion
- Less than a 10% probability of unacceptable performance for a ground motion equal to 150% of the DBE ground motion.

The ASCE approach considers the seismic response resulting from both a 10,000-year (1.0 E-4 annual probability) and a 100,000-year (1.0 E-5 annual probability) earthquake. If the difference in seismic response between the 10,000-year and the 100,000-year earthquakes is relatively small, then the 10,000-year earthquake is used as the DBE. The difference between the design level and the performance level is accounted for by the relatively low probability of unacceptable performance of SSCs that are subjected to design earthquake loads. Conservatism in design factors of safety and elasticity of the structures associated with design codes contribute to the low probability of unacceptable performance.

At the NEF site, the 100,000-year earthquake, 0.31g, is substantially larger than the 10,000-year event, 0.151g. Therefore, the 10,000-year earthquake is adjusted by an amplification factor to define the DBE as required by ASCE 43-05. The horizontal ground acceleration of the NEF DBE was determined to be 0.1611g. Because the amplification factor can vary with frequency, the spectral shape of the DBE resonse is somewhat different from that of the 10,000-year earthquake at all frequencies. Figure 3.2-32 shows the relationship between the 10,000-year, DBE, and 100,000-year earthquake spectra. For reference, the 250-year and 475-year spectra are also included in the plot.

3.2.6.6 SBM Building Design

The SBM-1001 is a safety-significant building which was designed and constructed in accordance with ASCE 43-05 and is the sole protection of important internal equipment and systems from extreme external phenomena including the DBE, tornado and high wind, roof snow load, and roof ponding and site flooding due to local intense precipitation. Future separations facilities will maintain these safety functions by requiring that the exterior steel and concrete buildings do not collapse during the current DBE, the licensing basis tornado and high wind loads, or the license basis local intense precipitation, flooding and snow loading, as described in 3.2.6.5, above.

To assure adequate structural design margin against collapse under these conditions, future separation facilities will be designed in accordance with the AISC ASD Manual of Steel Construction and ACI 318, Building Code Requirements for Structural Concrete, with the additional requirement that primary stresses during the extreme external loads will be limited to yield strength levels in order to assure elastic response of the buildings. In addition, the building design analysis will be performed in accordance with accepted industry standards, including ASCE 4, Seismic Analysis of Safety-Related Nuclear Structure, and ASCE 7, Minimum Design Loads for Building and Other Structures. The design analyses will be performed under a QA Level 1 (QL-1) program. Construction of these facilities will be in accordance with the graded QL-1G program described in the QAPD. These design and quality requirements will provide substantial margin against collapse.

The DBE for the future separations facilities will remain the current ASCE 43-05 ground motion seismic response spectra based on a seismic safety goal of 1E-5 annual probability, as described in 3.2.6.5, above.

3.2.7 Stability of Subsurface Materials

Detailed information about soil composition across the NEF site, including N-values, can be found in Appendices A and C of the Geotechnical Report (NTS Report 114489-G-01, Rev. 00). Allowable bearing pressures can be found in Table 5.8-2 and Figures 5.8-1 and 5.8-2 of the Geotechnical Report, and these values are based on the assumptions in Section 5.8 of the report. The California Bearing Ratio (CBR) test results can be found in Section 5.6.1 of the report. Table 5.9-4 of the report gives the maximum dry density values. A discussion of the soil's Young's modulus and a plot of the soil's Young's modulus can be found in Section 5.9.3 and Figure 5.9-4 of the report, respectively. Information on Atterberg limits can be found in Table 2-2 and Figure 3-5 of the report. A graph of the percentage of soil particles passing No. 200 sieve size vs. elevation is given in Figure 2-3 of the report.

The surface deposits silty sands will be removed to expose the more firm soil structures. Due consideration will be given to settlement and differential settlement during final design.

To support the final design of the NEF, as documented in the Geotechnical Report, additional soil borings were collected from the NEF site. Laboratory testing was performed on soil samples and additional in-situ testing was performed to determine static and dynamic soil properties. Using the soil information obtained, the following activities were conducted.

- The assessment of soil liquefaction potential was performed using the applicable guidance of Regulatory Guide 1.198, Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites.

- Allowable bearing pressures provided in the ISA Summary were refined using the applicable methods of Naval Facilities Engineering Command Design Manual NAVFAC DM-7.02, Foundations and Earth Structures; Foundation Engineering Handbook, H.F. Winterkorn and H.Y. Fang; or Foundation Analysis and Design, J.E. Bowles.
- Building settlement analysis was performed using the applicable methods of NAVFAC DM-7.01, Soil Mechanics; and Foundation Engineering Handbook, H.F. Winterkorn and H.Y. Fang. The acceptance criteria for the building settlement analysis was based on Urenco design criteria for allowable total and differential settlement of equipment and buildings.

3.2.7.1 Liquefaction Susceptibility

According to the Geotechnical Report (NTS Report No. 114489-G-01, Rev. 00), there is no potential for liquefaction of the soils beneath the NTS site due to shaking caused by the design earthquake. Soils to depths of up to 30.5 m (100 ft) at the NEF site are dry, damp, or moist and, consequently, they have no potential for liquefaction, as evidenced by SPT blow counts that generally exceed 100 flows/ft, and it extends from a depth of about 12 m (40 ft) to greater than 305 m (1000 ft) beneath the ground surface at the NEF site. Ground water may be at a depth of 183 m (600 ft). These subsurface soil and ground water conditions indicate that there is no potential for liquefaction to occur at the NEF site due to shaking caused by the design earthquake.

3.2.8 References

Edition of Codes, Standards, NRC Documents, etc that are not listed below are given in Table 3.0-1.

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3.2.9 Section 3.2 Tables

Table 3.2-1 Population and Population Projections, 1970-2040

	Area				
Topic	**Lea County, NM**	**Andrews County, TX**	**Lea-Andrews Combined**	**New Mexico**	**Texas**
Population/Projected Growth					
1970	49,554	10,372	59,926	1,017,055	11,198,567
1980	55,993	13,323	69,316	1,303,303	14,225,512
1990	55,765	14,338	70,103	1,515,069	16,986,510
2000	55,511	13,004	68,515	1,819,046	20,851,820
2010	60,702	15,572	76,274	2,091,675	23,812,815
2020	62,679	16,497	79,176	2,358,278	26,991,548
2030	64,655	17,423	82,078	2,624,881	30,170,281
2040	66,631	18,348	84,979	2,891,483	33,349,013
Percent Change					
1970-1980	13.0	28.5	15.7	28.1	27.0
1980-1990	-0.4	7.6	1.1	16.2	19.4
1990-2000	-0.5	-9.3	-2.3	20.1	22.8
2000-2010	9.4	19.7	11.3	15.0	14.2
2010-2020	3.3	5.9	3.8	12.7	13.3
2020-2030	3.2	5.6	3.7	11.3	11.8
2030-2040	3.1	5.3	3.5	10.2	10.5

Source: U. S. Census Bureau

Table 3.2-2 Educational Facilities Near the Site

School	Grades	Distance km (mi)	Direction	Population	Student-Teacher Ratio
Lea County, New Mexico					
Eunice High School	9-12	8.6 (5.3)	W	207	16:1
Caton Middle School	6-8	8.6 (5.3)	W	128	15:1
Mettie Jordan Elementary School	DD, K-5	8.6 (5.3)	W	269	21:1
Eunice Holiness Academy	1-12	8.2 (5.1)	W	14	6:1

Note: DD = Development Delayed Class

Source: Eunice School District
National Center for Educational Statistics
U.S. Census Bureau

Table 3.2-3 Land Use Within 8 km (5 mi) of the Site

Classification	Area						Percent	Description
	(Hectares)			(Acres)				
	New Mexico	Texas	Total	New Mexico	Texas	Total		
Built Up	243	0	243	601	0	601	1.2	Residential; industrial; commercial services
Rangeland	12,714	7,213	19,927	31,415	17,823	49,238	98.5	Herbaceous rangeland; shrub and brush rangeland; mixed rangeland
Barren	69	0	69	170	0	170	0.3	Bare exposed rock; transitional areas; beaches; sandy areas other than beaches
Total	13,026	7,213	20,239	32,186	17,823	50,009	100.0	

Table 3.2-4 Agriculture Census, Crop, and Livestock Information

Information	County			
	Lea (New Mexico)		Andrews (Texas)	
Census Data (1992 & 1997)	1997	1992	1997	1992
Number of Farms	528	544	142	134
Total Land in Farms ha (acres)	810,161 (2,001,931)	869,861 (2,149,450)	335,431 (828,859)	389,545 (962,576)
Avg. Farm Size ha (acres)[1]	1,535 (3,792)	1,599 (3,951)	2,362 (5,837)	2,907 (7,183)
Crop Annual Average Yields (Most Current)	Area Harvested Hectares (Acres) in 2001	Yield per Hectare (Acre) in 2001	Area Harvested Hectares (Acres) in 2002	Yield per Unit Area in 2001
Chili Peppers	324 (800)	4.49 MT/ha (2.0 tons/acre)	0	0
Wheat	3,035 (7,500)	3.91 m^3/ha (45.0 bu/acre)	81 (200)	2.61 m^3/ha (30 bu/acre)
Grain Sorghum	688 (1,700)	3.66 m^3/ha (42.1 bu/acre)	688 (1,700)	1,384 kg/ha (1,235 lb/acre)
Peanuts	5,828 (14,400)	3,182 kg/ha (2,840 lb/acre)	2,266 (5,600)	4,521 kg/ha (4,035 lb/acre)
All Hay	4,047 (10,000)	10.9 MT/ha (4.72 tons/acre)	0	0
Alfalfa Hay	2,428 (6,000)	13.6 MT/ha (6.0 tons/acre)	0	0
Pecans[2]	213 (526)	0	0	0
Upland Cotton	8,984 (22,200)	703 kg/ha (627 lb/acre)	7,811 (19,300)	435 kg/ha (388 lb/acre)
Livestock (Most Current)	Number in 2001		Number in 2002	
All Cattle	82,000		13,000	
Beef Cows	27,000		6,000	
Milk Cows	25,000		0	
Other Cattle (includes cattle on feed)	30,000		0	
Sheep and Lambs	4,000		0	

[1] Average Value per ha (acre) [1998]: New Mexico $536 ($217)/Texas $1,465 ($593) (USDA, National Agricultural Statistical Service)

[2] 1997 Census Data

Table 3.2-5 Midland-Odessa, Texas, Wind Data 1961-1990

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean Speed m/sec (mi/hr)	4.6 (10.4)	5.0 (11.2)	5.5 (12.4)	5.6 (12.6)	5.5 (12.4)	5.5 (12.2)	4.8 (10.7)	4.4 (9.9)	4.4 (9.9)	4.4 (9.9)	4.6 (10.3)	4.5 (10.1)	4.9 (11.0)
Prevailing Direction degrees from True North	180	180	180	180	180	160	160	160	160	180	180	180	180
Max 5-second speed m/sec (mi/hr)	22.8 (51.0)	23.2 (52.0)	24.1 (54.0)	26.4 (59.0)	24.6 (55.0)	21.9 (49.0)	26.4 (59.0)	28.6 (64.0)	31.3 (70.0)	20.6 (46.0)	20.1 (45.0)	21.9 (49.0)	31.3 (70.0)

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Table 3.2-6 Roswell, New Mexico, Wind Data 1961-1990

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Mean Speed m/sec (mi/hr)	3.1 (6.9)	3.6 (8.1)	4.2 (9.5)	4.4 (9.8)	4.3 (9.6)	4.3 (9.6)	3.8 (8.5)	3.4 (7.7)	3.4 (7.6)	3.3 (7.3)	3.2 (7.2)	3.1 (6.9)	3.7 (8.2)
Prevailing Direction degrees from True North	360	160	160	160	160	160	140	140	160	160	160	360	160
Max 5-second speed m/sec (mi/hr)	24.1 (54.0)	24.1 (54.0)	24.1 (54.0)	26.4 (59.0)	24.6 (55.0)	27.7 (62.0)	26.4 (59.0)	20.1 (45.0)	22.8 (51.0)	21.5 (48.0)	23.7 (53.0)	22.8 (51.0)	27.7 (62.0)

Local Climatological Data Annual Summary with Comparative Data for Roswell, New Mexico, National Oceanic and Atmospheric Administration, 2002.

Table 3.2-7 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution For All Stability Classes Combined

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 2.53 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	119	702	722	563	225	57	2388
NNE	71	291	509	556	207	58	1692
NE	64	285	645	776	272	61	2103
ENE	51	382	738	726	170	27	2094
E	69	623	1176	713	95	15	2691
ESE	72	589	1061	557	75	12	2366
SE	70	931	1266	818	134	18	3237
SSE	127	1156	1555	1391	371	48	4648
S	168	1755	2763	3178	820	100	8784
SSW	100	813	1276	807	133	7	3136
SW	61	446	943	757	115	23	2345
WSW	68	356	667	637	191	78	1997
W	84	331	577	517	207	171	1887
WNW	77	244	281	269	75	51	997
NW	91	332	350	224	69	38	1104
NNW	79	500	365	228	80	20	1272
SubTotal	1371	9736	14894	12717	3239	784	42741

Table 3.2-8 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class A

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 0.06 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	3	16	0	0	0	0	19
NNE	3	7	0	0	0	0	10
NE	0	8	0	0	0	0	8
ENE	2	12	0	0	0	0	14
E	3	15	0	0	0	0	18
ESE	3	8	0	0	0	0	11
SE	2	10	0	0	0	0	12
SSE	0	10	0	0	0	0	10
S	3	16	0	0	0	0	19
SSW	2	9	0	0	0	0	11
SW	0	12	0	0	0	0	12
WSW	1	6	0	0	0	0	7
W	0	5	0	0	0	0	5
WNW	0	2	0	0	0	0	2
NW	1	7	0	0	0	0	8
NNW	0	5	0	0	0	0	5
SubTotal	21	145	0	0	0	0	171

Table 3.2-9 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class B

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 0.11 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	20	43	22	0	0	0	85
NNE	17	25	19	0	0	0	61
NE	16	32	22	0	0	0	70
ENE	14	46	36	0	0	0	96
E	6	69	62	0	0	0	137
ESE	17	50	44	0	0	0	111
SE	9	48	45	0	0	0	102
SSE	15	54	64	0	0	0	133
S	25	96	138	0	0	0	259
SSW	12	53	59	0	0	0	124
SW	14	42	49	0	0	0	105
WSW	12	43	43	0	0	0	98
W	16	51	17	0	0	0	84
WNW	11	25	13	0	0	0	49
NW	18	21	14	0	0	0	53
NNW	15	27	9	0	0	0	51
SubTotal	235	722	652	-5	-5	24.5	1618

Table 3.2-10 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class C

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 0.12 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	9	54	124	20	8	3	218
NNE	3	36	87	37	5	1	169
NE	5	37	95	46	11	3	197
ENE	0	52	93	43	4	1	193
E	2	54	164	50	7	0	277
ESE	4	41	147	60	7	0	259
SE	3	36	179	109	10	1	338
SSE	1	65	264	199	52	5	586
S	6	103	527	408	95	19	1158
SSW	5	82	266	124	13	1	491
SW	1	59	238	115	11	2	426
WSW	3	43	180	61	22	7	316
W	5	39	100	76	21	10	251
WNW	4	36	57	25	7	1	130
NW	7	21	51	21	4	0	104
NNW	4	32	48	8	8	3	103
SubTotal	60	787	2616	1397	280	81.5	5216

Table 3.2-11 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class D

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 0.18 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	8	112	308	543	217	54	1242
NNE	14	65	302	519	202	57	1159
NE	7	79	389	730	261	58	1524
ENE	6	104	426	683	166	26	1411
E	7	108	550	663	88	15	1431
ESE	13	95	458	497	68	12	1143
SE	5	92	514	709	124	17	1461
SSE	11	98	618	1192	319	43	2281
S	13	151	949	2770	725	81	4689
SSW	3	74	369	683	120	6	1255
SW	1	46	259	642	104	21	1073
WSW	2	42	182	576	169	71	1042
W	4	49	177	441	186	161	1018
WNW	5	29	81	244	68	50	477
NW	3	30	95	203	65	38	434
NNW	7	47	121	220	72	17	484
SubTotal	107	1218	5794	11310	2949	751.5	22124

Table 3.2-12 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class E

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 0.00 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	0	133	268	0	0	0	401
NNE	0	64	101	0	0	0	165
NE	0	66	139	0	0	0	205
ENE	0	81	183	0	0	0	264
E	0	143	400	0	0	0	543
ESE	0	131	412	0	0	0	543
SE	0	236	528	0	0	0	764
SSE	0	259	609	0	0	0	868
S	0	380	1149	0	0	0	1529
SSW	0	145	582	0	0	0	727
SW	0	65	397	0	0	0	462
WSW	0	60	262	0	0	0	322
W	0	42	283	0	0	0	325
WNW	0	36	130	0	0	0	166
NW	0	50	190	0	0	0	240
NNW	0	98	187	0	0	0	285
SubTotal	-2	1986	5816	-5	-5	24.5	7809

Table 3.2-13 Midland-Odessa Five Year (1987-1991) Annual Joint Frequency Distribution Stability Class F

Jan. 1, 1987-Dec. 31, 1991
Wind Speed (mi/hr)
Calm = 2.07 percent

Direction	1-3	4-7	8-12	13-18	19-24	≥ 24.5	Total
N	79	344	0	0	0	0	423
NNE	34	94	0	0	0	0	128
NE	36	63	0	0	0	0	99
ENE	29	87	0	0	0	0	116
E	51	234	0	0	0	0	285
ESE	35	264	0	0	0	0	299
SE	51	509	0	0	0	0	560
SSE	100	670	0	0	0	0	770
S	121	1009	0	0	0	0	1130
SSW	78	450	0	0	0	0	528
SW	45	222	0	0	0	0	267
WSW	50	162	0	0	0	0	212
W	59	145	0	0	0	0	204
WNW	57	116	0	0	0	0	173
NW	62	203	0	0	0	0	265
NNW	53	291	0	0	0	0	344
SubTotal	938	4860	-4	-5	-5	24.5	5803

Table 3.2-14 Hobbs, New Mexico, Precipitation Data

Precip cm (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average	1.3 (0.51)	1.7 (0.66)	1.2 (0.48)	2 (0.78)	6.6 (2.58)	5.2 (2.03)	6.1 (2.42)	6.4 (2.52)	8 (3.13)	3.7 (1.45)	2.2 (0.87)	1.8 (0.72)	46.1 (18.15)
Max	5.2 (2.03)	5.6 (2.21)	7.6 (2.98)	7.3 (2.86)	35.1 (13.83)	13.6 (5.37)	23.9 (9.41)	23 (9.06)	33 (12.99)	20.7 (8.15)	11 (4.33)	12.9 (5.08)	35.1 (13.83)
Min	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.6 (0.22)	0.3 (0.11)	0.2 (0.08)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

Table 3.2-15 Midland-Odessa, Texas, Precipitation Data

1961-1990

Precip cm (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average	1.3 (0.53)	1.5 (0.58)	1.1 (0.42)	1.9 (0.73)	4.5 (1.79)	4.3 (1.71)	4.8 (1.89)	4.5 (1.77)	5.9 (2.31)	4.5 (1.77)	1.7 (0.65)	1.7 (0.65)	37.6 (14.8)
Max	9.3 (3.66)	6.5 (2.55)	7.3 (2.86)	7.2 (2.85)	19.4 (7.63)	10.0 (3.93)	21.6 (8.5)	11.3 (4.43)	24.6 (9.7)	18.9 (7.45)	5.9 (2.32)	8.4 (3.3)	24.6 (9.7)
Min	0.0 (0.0)	0.0 (0.0)	T T	0.0 (0.0)	0.1 (0.02)	0.03 (0.01)	T T	0.1 (0.05)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	T T	0.0 (0.0)
Max in 24 hours	2.9 (1.15)	3.4 (1.32)	5.6 (2.2)	4.1 (1.62)	12.1 (4.75)	7.8 (3.07)	15.2 (5.99)	6.1 (2.41)	11.1 (4.37)	9.1 (3.59)	5.5 (2.16)	2.3 (0.9)	15.2 (5.99)

T = trace amount

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Table 3.2-16 Roswell, New Mexico, Precipitation Data

Precip cm (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average	1.0 (0.39)	1.0 (0.41)	0.9 (0.35)	1.5 (0.58)	3.3 (1.30)	4.1 (1.62)	5.1 (1.99)	5.9 (2.31)	5.0 (1.98)	3.3 (1.29)	1.3 (0.53)	1.5 (0.59)	33.9 (13.34)
Max	2.6 (1.03)	5.1 (2.02)	7.2 (2.84)	6.3 (2.48)	11.6 (4.57)	12.8 (5.02)	17.5 (6.88)	16.5 (6.48)	16.7 (6.58)	15.0 (5.91)	5.4 (2.11)	7.8 (3.07)	17.5 (6.88)
Min	0.1 (0.03)	0.0 (0.0)	0.0 (0.0)	0.03 (0.01)	T T	0.1 (0.02)	0.03 (0.01)	0.2 (0.07)	0.1 (0.05)	T T	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Max in 24 hours	1.7 (0.67)	3.6 (1.41)	5.6 (2.22)	5.7 (2.24)	4.5 (1.77)	7.7 (3.05)	12.5 (4.91)	10.0 (3.94)	6.9 (2.71)	9.9 (3.89)	3.4 (1.33)	2.8 (1.1)	12.5 (4.91)

T = trace amount

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Table 3.2-17 Midland-Odessa, Texas, Snowfall Data

1961-1990

Snowfall cm (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average	5.6 (2.2)	1.8 (0.7)	0.5 (0.2)	0.3 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.* (0.*)	1.3 (0.5)	3.6 (1.4)	13.0 (5.1)
Max	22.9 (9.0)	9.9 (3.9)	15.0 (5.9)	5.1 (2.0)	T T	T T	T T	T T	T T	1.5 (0.6)	20.3 (8.0)	24.9 (9.8)	24.9 (9.8)
Max in 24 hours	17.3 (6.8)	9.9 (3.9)	12.7 (5.0)	5.1 (2.0)	T T	T T	T T	T T	T T	1.5 (0.6)	15.2 (6.0)	24.9 (9.8)	24.9 (9.8)

T = trace amount

0.* indicates the value is between 0.0 and 1.3 cm (0.0 and 0.05 in)

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Table 3.2-18 Roswell, New Mexico, Snowfall Data

1961-1990

Snowfall cm (in)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average	7.9 (3.1)	6.6 (2.6)	2.3 (0.9)	1.0 (0.4)	0.* (0.*)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.8 (0.3)	3.3 (1.3)	8.4 (3.3)	30.2 (11.9)
Max	26.4 (10.4)	42.9 (16.9)	12.2 (4.8)	13.5 (5.3)	2.0 (0.8)	2.5 (1.0)	0.0 (0.0)	0.0 (0.0)	2.5 (1.0)	10.7 (4.2)	31.2 (12.3)	53.3 (21.0)	53.3 (21.0)
Max in 24 hours	18.5 (7.3)	41.9 (16.5)	12.2 (4.8)	10.2 (4.0)	5.1 (2.0)	2.5 (1.0)	0.0 (0.0)	0.0 (0.0)	2.5 (1.0)	7.9 (3.1)	16.0 (6.3)	24.6 (9.7)	41.9 (16.5)

0.* indicates the value is between 0.0 and 1.3 cm (0.0 and 0.05 in)

Local Climatological Data Annual Summary with Comparative Data for Roswell, New Mexico, National Oceanic and Atmospheric Administration, 2002.

Table 3.2-19 Straight Wind Hazard Assessment

Annual Probability	Expected Wind Speed km/hr (mi/hr)	Upper Bound Wind Speed km/hr (mi/hr)	Lower Bound Wind Speed km/hr (mi/hr)
1E-01	134 (83)	146 (91)	119 (74)
1E-02	162 (101)	188 (117)	138 (86)
1E-03	193 (120)	230 (143)	156 (97)
1E-04	222 (138)	271(169)	174 (108)
1E-05	252 (157)	312 (194)	191 (119)
1E-06	282 (175)	354 (220)	209 (130)

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1931	8	16	-104.60	30.70			6.00	M	240.3	149.3	UTIG
1949	5	23	-105.20	34.60			4.50	M	310.0	192.6	NMTH
1955	1	27	-104.50	30.60			3.30	M	244.0	151.6	UTIG
1962	3	6	-104.80	31.20			3.50	M	212.3	131.9	UTIG
1963	12	19	-104.27	34.82			3.40	M	287.0	178.3	NMTR
1964	2	11	-103.94	34.23			2.10	M	214.2	133.1	NMTR
1964	3	3	-103.60	34.84			2.90	M	271.0	168.4	NMTR
1964	6	19	-105.77	32.95			1.90	M	257.4	159.9	NMTR
1964	8	14	-102.94	31.97			1.90	M	53.1	33.0	NMTR
1964	9	7	-102.92	31.94			1.60	M	56.9	35.3	NMTR
1964	11	8	-103.10	31.90			3.00	M	59.5	37.0	UTIG
1964	11	21	-103.10	31.90			3.10	M	59.5	37.0	UTIG
1964	11	27	-102.97	31.89			1.90	M	61.1	38.0	NMTR
1965	1	21	-102.85	32.02			1.30	M	50.9	31.6	NMTR
1965	2	3	-103.10	31.90			3.30	M	59.5	37.0	UTIG
1965	8	30	-103.00	31.90			3.50	M	60.0	37.3	UTIG
1966	8	14	-103.00	31.90			3.40	M	60.0	37.3	UTIG
1966	9	17	-103.98	34.89			2.70	M	284.6	176.9	NMTR
1966	10	6	-104.12	35.13			2.90	M	314.4	195.4	NMTR
1966	11	26	-105.44	30.95			3.50	M	277.5	172.4	NMTR
1968	3	23	-105.91	32.67			2.60	M	265.7	165.1	NMTR
1968	5	2	-105.24	33.10			2.60	M	214.3	133.1	NMTR
1969	6	1	-105.21	34.20			1.90	M	277.7	172.5	NMTR
1969	6	8	-105.19	34.15			2.60	M	272.8	169.5	NMTR
1971	7	30	-103.00	31.72	10.0	6.2	3.00	mb	79.9	49.6	ANSS
1971	7	31	-103.06	31.70	10.0	6.2	3.40	mb	81.4	50.6	ANSS
1971	9	24	-103.20	31.60			3.20	M	93.5	58.1	UTIG
1972	7	26	-104.01	32.57			3.10	M	88.3	54.9	NMTR
1973	3	17	-102.36	31.59			2.50	M	115.7	71.9	NMTR
1973	8	2	-105.56	31.04			3.60	M	280.7	174.5	NMTR
1973	8	4	-103.22	35.11			3.00	M	296.6	184.3	NMTR
1974	7	31	-104.19	33.11			0.00	M	128.0	79.5	NMTR
1974	10	2	-100.86	31.87			0.00	M	217.7	135.3	NMTR
1974	10	27	-104.83	30.63			0.00	M	259.6	161.3	NMTR
1974	11	12	-102.67	32.14			0.00	M	51.0	31.7	NMTR
1974	11	21	-102.75	32.07			0.00	M	51.0	31.7	NMTR
1974	11	22	-101.26	32.94			0.00	M	179.2	111.3	NMTR
1974	11	22	-105.21	33.78			0.00	M	247.7	153.9	NMTR
1974	11	28	-103.94	32.58			0.00	M	82.2	51.1	NMTR
1974	11	28	-104.14	32.31	5.0	3.1	3.90	mb	100.4	62.4	ANSS

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1974	12	30	-103.10	30.90			3.70	M	170.5	106.0	UTIG
1975	1	30	-103.08	30.95			2.10	M	165.1	102.6	NMTR
1975	2	2	-103.19	35.05			3.00	M	290.7	180.6	NMTR
1975	4	8	-101.69	32.18			0.00	M	133.9	83.2	NMTR
1975	7	25	-102.62	29.82			0.00	M	293.4	182.3	NMTR
1975	8	1	-104.60	30.49			0.00	M	259.5	161.3	NMTR
1975	8	1	-104.00	31.40			3.00	M	143.9	89.4	UTIG
1975	8	3	-104.45	30.71			0.00	M	231.0	143.5	NMTR
1975	10	10	-105.02	33.36			0.00	M	207.4	128.9	NMTR
1975	12	12	-102.31	31.61			3.00	M	117.5	73.0	NMTR
1976	1	10	-102.76	31.79			0.00	M	78.4	48.7	NMTR
1976	1	15	-102.32	30.98			0.00	M	176.6	109.7	NMTR
1976	1	19	-103.09	31.90			3.50	M	59.5	37.0	UTIG
1976	1	21	-102.29	30.95			0.00	M	180.8	112.4	NMTR
1976	1	22	-103.07	31.90	1.0	0.6	2.80	un	59.5	37.0	ANSS
1976	1	25	-103.08	31.90	2.0	1.2	3.90	un	59.3	36.8	ANSS
1976	1	28	-100.89	31.99			0.00	M	211.8	131.6	NMTR
1976	2	4	-103.53	31.68			0.00	M	94.1	58.4	NMTR
1976	2	14	-102.47	31.63			0.00	M	106.2	66.0	NMTR
1976	3	5	-102.25	31.66			0.00	M	116.7	72.5	NMTR
1976	3	15	-102.58	32.50			0.00	M	47.3	29.4	NMTR
1976	3	18	-102.96	32.33			0.00	M	16.5	10.3	NMTR
1976	3	20	-104.94	31.27			0.00	M	217.4	135.1	NMTR
1976	3	20	-103.06	32.22			0.00	M	24.4	15.2	NMTR
1976	3	27	-103.07	32.22			0.00	M	23.7	14.7	NMTR
1976	4	3	-103.10	31.24			0.00	M	132.5	82.3	NMTR
1976	4	12	-103.00	32.27			0.00	M	20.2	12.5	NMTR
1976	4	21	-102.89	32.25			0.00	M	27.7	17.2	NMTR
1976	4	30	-103.09	31.98			0.00	M	50.7	31.5	NMTR
1976	4	30	-103.11	31.92			0.00	M	57.6	35.8	NMTR
1976	5	1	-103.06	32.37			0.00	M	8.0	5.0	NMTR
1976	5	3	-105.66	32.41			0.00	M	241.7	150.2	NMTR
1976	5	3	-103.20	32.03			0.00	M	47.0	29.2	NMTR
1976	5	3	-103.03	32.03			0.00	M	45.6	28.3	NMTR
1976	5	4	-103.23	31.86			0.00	M	65.3	40.6	NMTR
1976	5	6	-103.18	31.97			0.00	M	53.1	33.0	NMTR
1976	5	6	-103.16	31.87			0.00	M	63.3	39.3	NMTR
1976	5	11	-102.92	32.29			0.00	M	22.2	13.8	NMTR
1976	5	21	-105.59	32.49			0.00	M	234.9	146.0	NMTR
1976	6	14	-102.49	31.52			0.00	M	116.5	72.4	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1976	6	15	-102.34	31.56			0.00	M	120.0	74.6	NMTR
1976	6	15	-102.37	31.60			0.00	M	115.0	71.5	NMTR
1976	7	28	-102.29	33.02			0.00	M	98.7	61.4	NMTR
1976	8	5	-101.73	30.87			0.00	M	216.3	134.4	NMTR
1976	8	5	-103.00	31.60			3.00	M	93.1	57.9	UTIG
1976	8	6	-102.59	31.78			2.10	M	86.3	53.6	NMTR
1976	8	10	-102.03	31.77			0.00	M	123.8	76.9	NMTR
1976	8	10	-102.06	31.79			0.00	M	119.5	74.3	NMTR
1976	8	25	-101.94	31.55			0.00	M	146.1	90.8	NMTR
1976	8	26	-102.01	31.84			0.00	M	120.8	75.1	NMTR
1976	8	30	-101.98	31.57			0.00	M	141.7	88.0	NMTR
1976	8	31	-102.18	31.46			0.00	M	137.4	85.4	NMTR
1976	9	3	-103.48	31.55			2.00	M	105.2	65.4	NMTR
1976	9	5	-102.74	32.23			0.00	M	39.3	24.4	NMTR
1976	9	17	-103.06	32.24			0.00	M	22.4	13.9	NMTR
1976	9	17	-102.50	31.40			3.10	M	127.4	79.2	UTIG
1976	9	19	-104.57	30.47			0.00	M	259.7	161.4	NMTR
1976	10	22	-102.16	31.55			0.00	M	131.6	81.8	NMTR
1976	10	23	-102.38	31.62			0.00	M	112.2	69.7	NMTR
1976	10	25	-102.53	31.84			0.00	M	84.3	52.4	NMTR
1976	10	26	-103.28	31.33			2.40	M	124.2	77.2	NMTR
1976	11	3	-102.27	30.92			0.00	M	185.6	115.3	NMTR
1976	12	12	-102.46	31.57			2.80	M	112.5	69.9	NMTR
1976	12	12	-102.49	31.61			1.90	M	107.3	66.6	NMTR
1976	12	15	-102.22	31.59			1.40	M	124.2	77.2	NMTR
1976	12	18	-103.02	31.62			1.80	M	90.8	56.4	NMTR
1976	12	19	-102.45	31.87			2.20	M	86.0	53.5	NMTR
1976	12	19	-103.14	32.25			1.80	M	20.9	13.0	NMTR
1976	12	19	-103.08	32.27			2.70	M	18.7	11.6	NMTR
1977	1	29	-104.59	30.58			0.00	M	250.3	155.5	NMTR
1977	2	4	-104.70	30.59			0.00	M	256.1	159.2	NMTR
1977	2	18	-103.05	32.24			0.00	M	21.7	13.5	NMTR
1977	3	5	-102.66	31.16			0.00	M	146.9	91.3	NMTR
1977	3	14	-101.01	33.04			0.00	M	204.7	127.2	NMTR
1977	3	20	-103.10	32.21			0.00	M	25.5	15.8	NMTR
1977	3	29	-103.28	31.60			0.00	M	94.2	58.5	NMTR
1977	4	3	-103.17	31.49			1.90	M	105.3	65.5	NMTR
1977	4	3	-103.20	31.47			0.00	M	107.8	67.0	NMTR
1977	4	4	-103.36	31.00			0.00	M	161.4	100.3	NMTR
1977	4	7	-103.05	32.19			0.00	M	27.7	17.2	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1977	4	7	-102.70	31.32			0.00	M	129.3	80.3	NMTR
1977	4	7	-102.94	31.35			0.00	M	120.9	75.1	NMTR
1977	4	12	-102.55	31.28			0.00	M	137.4	85.4	NMTR
1977	4	17	-102.35	31.50			0.00	M	124.7	77.5	NMTR
1977	4	18	-103.25	31.60			0.00	M	93.7	58.2	NMTR
1977	4	22	-103.02	32.18			0.00	M	28.8	17.9	NMTR
1977	4	25	-102.81	32.07			0.00	M	47.9	29.8	NMTR
1977	4	26	-103.08	31.90	4.0	2.5	3.30	un	59.3	36.8	ANSS
1977	4	28	-102.52	31.83			0.00	M	86.1	53.5	NMTR
1977	4	28	-101.99	31.87			0.00	M	120.6	75.0	NMTR
1977	4	29	-102.65	31.77			0.00	M	84.0	52.2	NMTR
1977	6	7	-100.75	33.06	5.0	3.1	4.00	un	228.5	142.0	ANSS
1977	6	8	-100.83	32.83			0.00	M	215.4	133.9	NMTR
1977	6	8	-100.82	32.92			0.00	M	218.4	135.7	NMTR
1977	6	8	-101.04	32.87			0.00	M	196.4	122.1	NMTR
1977	6	17	-100.95	32.90			2.70	M	206.1	128.1	NMTR
1977	6	28	-103.30	31.54			2.30	M	101.6	63.1	NMTR
1977	7	1	-103.34	31.50			2.00	M	106.7	66.3	NMTR
1977	7	11	-102.62	31.80			0.00	M	83.1	51.6	NMTR
1977	7	11	-102.68	31.79			0.00	M	81.4	50.6	NMTR
1977	7	12	-102.64	31.77			0.00	M	84.6	52.6	NMTR
1977	7	18	-102.70	31.78			0.00	M	81.4	50.6	NMTR
1977	7	22	-102.72	31.80			0.00	M	78.2	48.6	NMTR
1977	7	22	-102.70	31.80			3.00	M	79.2	49.2	UTIG
1977	7	24	-102.70	31.79			0.00	M	79.7	49.5	NMTR
1977	8	20	-103.33	31.60			1.90	M	95.7	59.5	NMTR
1977	8	21	-104.91	30.54			0.00	M	272.4	169.3	NMTR
1977	10	13	-100.81	32.91			2.20	M	218.8	135.9	NMTR
1977	10	17	-102.46	31.57			1.80	M	112.6	69.9	NMTR
1977	11	14	-104.96	31.52			0.00	M	203.7	126.6	NMTR
1977	11	27	-101.14	33.02			0.00	M	192.7	119.8	NMTR
1977	11	28	-100.84	32.95	5.0	3.1	3.50	un	217.4	135.1	ANSS
1977	12	16	-102.40	31.52			0.00	M	120.2	74.7	NMTR
1977	12	21	-102.41	31.52			0.00	M	120.3	74.7	NMTR
1977	12	31	-102.46	31.60			2.10	M	109.7	68.2	NMTR
1978	1	2	-102.53	31.60			2.20	M	106.3	66.1	NMTR
1978	1	12	-102.30	31.49			0.00	M	128.1	79.6	NMTR
1978	1	15	-101.70	31.36			0.00	M	177.0	110.0	NMTR
1978	1	18	-103.23	31.61			0.00	M	92.9	57.7	NMTR
1978	1	19	-103.71	32.56			0.00	M	60.5	37.6	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1978	2	5	-102.60	31.89			0.00	M	76.2	47.4	NMTR
1978	2	5	-104.55	31.41			0.00	M	179.5	111.5	NMTR
1978	2	18	-104.69	31.21			2.30	M	203.8	126.6	NMTR
1978	3	2	-103.06	32.82			1.50	M	42.5	26.4	NMTR
1978	3	2	-102.38	31.58			3.30	M	115.4	71.7	NMTR
1978	3	2	-102.61	31.59			2.10	M	103.9	64.6	NMTR
1978	3	2	-102.56	31.55			3.50	M	109.9	68.3	UTIG
1978	3	19	-102.49	31.47			1.60	M	120.5	74.9	NMTR
1978	6	16	-100.80	33.00			3.40	M	222.1	138.0	UTIG
1978	6	16	-100.77	33.03	10.0	6.2	5.30	un	226.1	140.5	ANSS
1978	6	29	-102.42	31.08			3.20	M	163.1	101.4	NMTR
1978	7	5	-102.20	31.61			0.00	M	123.2	76.5	NMTR
1978	7	18	-104.36	30.36			0.00	M	260.4	161.8	NMTR
1978	7	21	-102.77	31.34			0.00	M	125.0	77.7	NMTR
1978	8	14	-102.18	31.58			2.20	M	127.4	79.2	NMTR
1978	9	29	-102.42	31.52			0.00	M	119.2	74.1	NMTR
1978	9	30	-102.17	31.36			0.00	M	146.7	91.1	NMTR
1978	10	2	-102.43	31.53			0.00	M	117.6	73.1	NMTR
1978	10	2	-102.19	31.51			0.00	M	132.5	82.3	NMTR
1978	10	2	-102.36	31.48			0.00	M	126.4	78.5	NMTR
1978	10	3	-102.99	31.90			0.00	M	59.7	37.1	NMTR
1978	10	6	-102.36	31.55			0.00	M	119.8	74.4	NMTR
1979	4	28	-104.72	30.47			0.00	M	267.7	166.3	NMTR
1979	7	17	-103.73	32.65			2.00	M	65.4	40.6	NMTR
1979	8	3	-100.81	32.87			2.40	M	217.5	135.1	NMTR
1980	1	21	-105.00	34.20			1.30	M	264.2	164.2	NMTR
1980	3	21	-102.34	31.57			1.60	M	118.5	73.6	NMTR
1981	8	13	-102.70	31.90			2.20	M	69.7	43.3	NMTR
1981	9	16	-105.23	33.72			1.80	M	245.2	152.4	NMTR
1982	1	4	-102.49	31.18	5.0	3.1	3.90	un	149.9	93.2	ANSS
1982	4	26	-100.84	33.02	5.0	3.1	2.80	un	218.8	136.0	ANSS
1982	5	1	-103.04	32.33			2.10	M	12.3	7.6	NMTR
1982	10	17	-102.71	30.90			2.00	M	174.0	108.1	NMTR
1982	10	26	-103.59	33.67			1.50	M	144.6	89.8	NMTR
1982	10	26	-103.61	33.63			1.50	M	141.3	87.8	NMTR
1982	11	25	-100.78	32.89			2.30	M	220.7	137.1	NMTR
1982	11	28	-100.84	33.00	5.0	3.1	3.30	un	218.4	135.7	ANSS
1983	1	9	-104.19	30.65			1.90	M	224.3	139.4	NMTR
1983	1	12	-105.19	34.32			1.50	M	286.7	178.2	NMTR
1983	1	29	-102.08	31.75			2.20	M	121.2	75.3	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1983	3	3	-104.35	29.96			2.80	M	299.6	186.2	NMTR
1983	6	5	-105.35	32.52			1.30	M	212.6	132.1	NMTR
1983	6	21	-103.58	33.63			1.60	M	140.9	87.5	NMTR
1983	7	21	-105.14	30.97			1.60	M	253.4	157.5	NMTR
1983	8	4	-105.14	32.57			1.30	M	193.4	120.2	NMTR
1983	8	19	-102.23	31.31			1.80	M	148.8	92.5	NMTR
1983	8	22	-105.08	34.06			1.30	M	258.6	160.7	NMTR
1983	8	23	-105.52	31.17			2.10	M	269.7	167.6	NMTR
1983	8	26	-102.53	33.62			1.60	M	140.9	87.5	NMTR
1983	8	29	-100.62	31.80			2.60	M	242.0	150.4	NMTR
1983	9	15	-104.43	34.92			3.10	M	302.6	188.1	NMTR
1983	9	29	-104.45	34.89			2.70	M	300.0	186.4	NMTR
1983	9	30	-103.97	30.57			1.70	M	224.0	139.2	NMTR
1983	12	1	-101.99	31.86			1.40	M	121.1	75.3	NMTR
1983	12	3	-103.32	30.97			2.10	M	164.1	102.0	NMTR
1983	12	26	-102.88	30.77			1.70	M	186.4	115.8	NMTR
1984	1	2	-102.12	31.81			1.80	M	114.4	71.1	NMTR
1984	1	3	-102.69	31.21			1.70	M	141.3	87.8	NMTR
1984	1	3	-103.04	30.76			2.00	M	186.3	115.8	NMTR
1984	1	16	-102.20	31.56			1.40	M	127.5	79.2	NMTR
1984	3	2	-104.84	30.81			1.90	M	245.5	152.5	NMTR
1984	3	23	-100.78	32.45			1.50	M	215.2	133.7	NMTR
1984	5	21	-102.59	31.14			1.30	M	151.3	94.0	NMTR
1984	5	21	-102.23	35.07	5.0	3.1	3.10	un	302.5	188.0	ANSS
1984	6	27	-102.48	31.22			2.00	M	146.5	91.0	NMTR
1984	7	17	-105.77	32.85			1.30	M	255.7	158.9	NMTR
1984	8	18	-103.56	30.78			1.80	M	189.8	118.0	NMTR
1984	8	24	-104.48	30.67			1.30	M	236.8	147.1	NMTR
1984	8	26	-104.27	30.38			2.10	M	254.4	158.1	NMTR
1984	9	11	-100.70	31.99	5.0	3.1	3.20	un	229.4	142.5	ANSS
1984	9	19	-100.69	32.03	5.0	3.1	3.00	un	229.3	142.5	ANSS
1984	9	27	-103.42	32.59			1.60	M	36.0	22.4	NMTR
1984	10	4	-102.70	33.58			1.30	M	132.3	82.2	NMTR
1984	10	4	-102.24	31.65			1.30	M	118.4	73.6	NMTR
1984	10	11	-100.56	31.95			2.40	M	243.2	151.1	NMTR
1984	10	27	-104.56	30.62			1.70	M	245.1	152.3	NMTR
1984	11	27	-105.41	33.57			1.60	M	250.6	155.7	NMTR
1984	12	4	-101.93	30.10			2.30	M	281.6	175.0	NMTR
1984	12	4	-103.21	32.64			2.10	M	25.4	15.8	NMTR
1984	12	4	-103.56	32.27	5.0	3.1	2.90	un	48.3	30.0	ANSS

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1984	12	12	-105.61	33.36			1.50	M	256.9	159.6	NMTR
1985	2	21	-100.75	32.88			1.40	M	223.3	138.7	NMTR
1985	2	21	-100.81	32.72			1.50	M	214.6	133.4	NMTR
1985	3	9	-105.12	33.97			1.30	M	254.4	158.1	NMTR
1985	5	3	-104.95	31.04			1.90	M	234.5	145.7	NMTR
1985	6	1	-102.83	31.06			1.50	M	154.6	96.0	NMTR
1985	6	2	-102.28	31.18			1.60	M	158.7	98.6	NMTR
1985	6	12	-103.90	34.64			1.60	M	255.9	159.0	NMTR
1985	8	2	-104.34	32.48			1.40	M	118.0	73.3	NMTR
1985	9	5	-103.77	33.66			1.80	M	150.1	93.3	NMTR
1985	9	18	-103.42	30.90			2.00	M	173.1	107.6	NMTR
1985	10	21	-101.88	32.04			1.30	M	121.3	75.4	NMTR
1985	11	13	-103.08	32.10			1.80	M	37.8	23.5	NMTR
1985	11	28	-101.99	31.61			1.80	M	138.2	85.9	NMTR
1985	12	5	-102.94	32.42			1.60	M	13.9	8.6	NMTR
1986	1	25	-100.73	32.06	5.0	3.1	2.90	un	224.3	139.4	ANSS
1986	1	30	-104.01	33.54			1.90	M	150.1	93.3	NMTR
1986	1	30	-100.69	32.07	5.0	3.1	3.30	un	228.0	141.7	ANSS
1986	2	7	-105.44	32.54			1.40	M	221.0	137.3	NMTR
1986	2	14	-100.76	31.53			2.60	M	240.9	149.7	NMTR
1986	3	1	-102.57	31.16			1.70	M	149.6	92.9	NMTR
1986	3	11	-105.08	32.11			2.00	M	190.7	118.5	NMTR
1986	3	21	-105.64	33.43			1.60	M	262.8	163.3	NMTR
1986	5	28	-105.12	31.76			1.60	M	205.8	127.9	NMTR
1986	6	12	-102.22	31.77			1.80	M	109.6	68.1	NMTR
1986	6	27	-102.01	32.06			2.20	M	109.3	67.9	NMTR
1986	7	9	-102.48	31.55			1.60	M	113.3	70.4	NMTR
1986	7	20	-105.00	33.47			1.50	M	212.8	132.2	NMTR
1986	8	2	-103.79	33.68			1.70	M	153.4	95.3	NMTR
1986	8	6	-103.03	33.86			2.40	M	158.4	98.5	NMTR
1986	8	14	-104.66	32.53			1.30	M	148.0	92.0	NMTR
1986	8	15	-103.43	33.14			1.70	M	84.2	52.3	NMTR
1986	8	29	-102.41	31.31			1.40	M	140.1	87.1	NMTR
1986	9	18	-102.37	31.51			1.80	M	123.2	76.5	NMTR
1986	10	18	-102.69	30.07			1.60	M	265.4	164.9	NMTR
1986	10	25	-102.13	31.60			1.70	M	129.0	80.2	NMTR
1986	11	3	-104.64	31.09			2.00	M	209.5	130.2	NMTR
1986	11	6	-104.58	32.55			1.60	M	140.4	87.2	NMTR
1986	11	17	-100.73	33.08			2.00	M	230.6	143.3	NMTR
1986	11	24	-102.16	31.68			2.00	M	121.1	75.3	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1986	12	6	-102.16	31.59			2.40	M	127.6	79.3	NMTR
1986	12	6	-102.23	31.47			2.10	M	133.9	83.2	NMTR
1986	12	6	-102.17	31.65			1.70	M	122.0	75.8	NMTR
1986	12	6	-102.09	31.72			2.20	M	122.6	76.2	NMTR
1986	12	15	-103.19	35.07			1.50	M	292.9	182.0	NMTR
1986	12	15	-102.02	31.76			1.50	M	125.0	77.7	NMTR
1987	1	25	-104.86	31.74			1.70	M	184.3	114.5	NMTR
1987	2	9	-103.45	30.69			2.30	M	196.8	122.3	NMTR
1987	2	9	-101.96	31.86			1.60	M	123.6	76.8	NMTR
1987	2	12	-101.94	31.66			1.60	M	137.9	85.7	NMTR
1987	2	17	-104.52	30.60			2.10	M	244.8	152.1	NMTR
1987	3	2	-105.08	30.78			1.80	M	263.6	163.8	NMTR
1987	3	3	-105.44	31.17			1.50	M	263.4	163.7	NMTR
1987	3	10	-105.66	31.13			1.50	M	282.7	175.7	NMTR
1987	3	26	-103.28	30.96			2.60	M	165.2	102.6	NMTR
1987	3	31	-104.95	31.52			2.80	M	203.4	126.4	NMTR
1987	4	23	-105.02	32.03			1.60	M	187.7	116.7	NMTR
1987	4	25	-105.22	33.97			1.90	M	261.2	162.3	NMTR
1987	4	29	-105.92	32.67			2.30	M	267.0	165.9	NMTR
1987	7	5	-104.77	30.85			2.00	M	237.5	147.6	NMTR
1987	7	23	-103.03	35.29			1.90	M	316.9	196.9	NMTR
1987	7	30	-103.87	34.54			1.50	M	244.4	151.9	NMTR
1987	8	4	-102.12	31.87			1.70	M	110.1	68.4	NMTR
1987	9	11	-103.62	33.61			2.00	M	139.1	86.4	NMTR
1987	9	21	-103.74	33.68			1.80	M	150.6	93.6	NMTR
1987	10	1	-105.16	30.47			1.60	M	294.1	182.7	NMTR
1987	10	1	-103.76	33.66			1.50	M	150.0	93.2	NMTR
1987	10	9	-104.59	31.07			1.40	M	208.4	129.5	NMTR
1987	10	31	-105.31	32.86			1.30	M	213.8	132.9	NMTR
1987	11	3	-103.71	33.70			1.30	M	151.6	94.2	NMTR
1987	11	17	-101.97	32.06			1.60	M	112.9	70.1	NMTR
1987	12	6	-102.76	31.83			1.60	M	74.2	46.1	NMTR
1987	12	20	-103.07	32.29			2.20	M	15.8	9.8	NMTR
1987	12	28	-102.25	31.47			2.10	M	133.3	82.8	NMTR
1987	12	29	-102.11	31.58			1.50	M	132.1	82.1	NMTR
1988	1	26	-102.42	31.24			2.30	M	146.4	90.9	NMTR
1988	2	14	-102.06	31.78			1.40	M	121.0	75.2	NMTR
1988	2	21	-103.02	30.45			1.40	M	220.3	136.9	NMTR
1988	2	27	-103.75	33.67			1.80	M	150.3	93.4	NMTR
1988	3	9	-102.44	31.24			1.70	M	146.0	90.7	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1988	3	15	-105.52	31.72			1.30	M	242.7	150.8	NMTR
1988	3	17	-102.20	31.66			1.60	M	119.8	74.4	NMTR
1988	4	5	-102.33	31.44			2.10	M	131.6	81.8	NMTR
1988	4	6	-102.09	31.94			1.30	M	107.9	67.1	NMTR
1988	5	3	-104.39	30.52			1.30	M	246.2	153.0	NMTR
1988	5	10	-105.20	30.96			1.40	M	258.4	160.6	NMTR
1988	5	27	-102.12	31.78			1.30	M	116.1	72.1	NMTR
1988	5	27	-102.02	32.06			1.30	M	108.3	67.3	NMTR
1988	7	4	-100.74	33.74			2.00	M	261.5	162.5	NMTR
1988	7	11	-103.25	35.28			1.90	M	316.6	196.7	NMTR
1988	7	20	-102.43	29.77			2.20	M	301.9	187.6	NMTR
1988	7	25	-104.91	31.98			1.50	M	178.9	111.2	NMTR
1988	7	26	-105.14	30.94			1.50	M	255.5	158.8	NMTR
1988	8	23	-102.02	32.26			1.50	M	101.1	62.8	NMTR
1988	9	15	-103.32	31.68			1.50	M	86.7	53.9	NMTR
1988	9	19	-102.45	32.46			2.00	M	59.3	36.8	NMTR
1988	10	2	-103.79	33.63			1.30	M	147.8	91.8	NMTR
1988	11	10	-102.40	31.55			1.90	M	117.3	72.9	NMTR
1989	1	9	-102.59	31.44			1.80	M	119.6	74.3	NMTR
1989	1	9	-102.12	31.78			1.30	M	116.5	72.4	NMTR
1989	1	20	-101.97	32.08			1.90	M	112.1	69.6	NMTR
1989	2	21	-103.39	35.29			2.30	M	318.4	197.8	NMTR
1989	3	19	-103.55	31.19			1.50	M	145.2	90.2	NMTR
1989	3	21	-102.33	31.42			1.50	M	133.5	83.0	NMTR
1989	3	30	-102.86	33.24			1.40	M	91.5	56.9	NMTR
1989	6	5	-102.09	32.10			2.10	M	100.1	62.2	NMTR
1989	6	23	-102.23	31.59			1.60	M	123.2	76.6	NMTR
1989	6	28	-105.08	30.93			2.30	M	252.3	156.8	NMTR
1989	7	13	-105.27	33.53			1.50	M	237.1	147.3	NMTR
1989	7	24	-100.93	32.92			1.60	M	208.3	129.5	NMTR
1989	7	25	-101.76	30.90			2.10	M	211.2	131.3	NMTR
1989	8	8	-102.70	31.30			2.30	M	131.3	81.6	NMTR
1989	8	16	-101.96	31.70			1.60	M	133.3	82.8	NMTR
1989	9	5	-102.50	34.25			2.50	M	208.9	129.8	NMTR
1989	11	2	-100.94	33.02			2.00	M	210.4	130.7	NMTR
1989	11	16	-103.12	35.11			2.60	M	296.7	184.4	NMTR
1989	12	7	-103.67	34.58			1.40	M	244.1	151.7	NMTR
1989	12	28	-101.06	31.70			2.10	M	207.6	129.0	NMTR
1989	12	28	-100.96	32.04			1.70	M	203.9	126.7	NMTR
1990	1	16	-105.32	31.74			1.80	M	224.4	139.4	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1990	3	4	-103.92	30.53			1.70	M	226.3	140.6	NMTR
1990	3	30	-100.53	32.96			2.30	M	245.1	152.3	NMTR
1990	3	30	-100.56	32.99			2.20	M	243.5	151.3	NMTR
1990	4	6	-103.36	31.51			1.90	M	106.3	66.0	NMTR
1990	5	10	-102.37	31.14			2.20	M	159.2	98.9	NMTR
1990	5	10	-101.96	32.13			1.60	M	110.9	68.9	NMTR
1990	5	16	-102.04	31.86			2.40	M	117.2	72.8	NMTR
1990	5	22	-102.09	30.24			2.20	M	261.5	162.5	NMTR
1990	6	22	-100.76	32.58			2.20	M	218.3	135.7	NMTR
1990	7	3	-102.22	31.44			1.50	M	137.6	85.5	NMTR
1990	7	13	-101.81	34.86			2.70	M	293.9	182.6	NMTR
1990	8	3	-100.69	32.21			3.40	M	225.6	140.2	NMTR
1990	8	9	-102.67	31.21			1.90	M	141.8	88.1	NMTR
1990	8	14	-102.26	31.39			1.80	M	139.8	86.9	NMTR
1990	8	25	-102.01	31.91			1.80	M	116.0	72.1	NMTR
1990	10	8	-105.12	30.94			1.30	M	254.0	157.8	NMTR
1990	12	20	-103.14	35.27			2.50	M	315.1	195.8	NMTR
1991	1	1	-105.27	32.44			1.60	M	205.4	127.6	NMTR
1991	1	29	-103.04	32.89			1.40	M	50.8	31.6	NMTR
1991	2	3	-104.49	32.81			1.30	M	137.7	85.6	NMTR
1991	2	3	-103.96	35.00			2.10	M	296.2	184.0	NMTR
1991	3	10	-103.97	30.47			2.10	M	234.3	145.6	NMTR
1991	3	10	-103.33	33.58			2.00	M	128.8	80.0	NMTR
1991	4	8	-103.13	34.98			2.10	M	282.4	175.5	NMTR
1991	5	16	-103.75	33.67			2.00	M	150.4	93.5	NMTR
1991	6	4	-102.31	32.05			2.00	M	83.9	52.1	NMTR
1991	7	16	-101.12	33.09			2.10	M	197.3	122.6	NMTR
1991	8	1	-104.02	34.59			2.70	M	254.6	158.2	NMTR
1991	8	7	-104.81	31.62			1.80	M	186.1	115.6	NMTR
1991	8	17	-100.99	32.09			2.00	M	200.2	124.4	NMTR
1991	9	22	-101.30	31.32			2.10	M	209.2	130.0	NMTR
1991	9	28	-103.77	33.63			1.70	M	147.3	91.6	NMTR
1991	9	30	-100.73	31.85			2.20	M	230.5	143.2	NMTR
1991	10	5	-105.41	31.38			2.20	M	248.6	154.5	NMTR
1992	1	2	-103.19	32.30			5.00	M	17.8	11.0	NMTR
1992	1	2	-103.19	32.30			1.80	M	17.8	11.0	NMTR
1992	1	2	-103.19	32.30			1.50	M	17.8	11.0	NMTR
1992	1	2	-103.19	32.30			2.40	M	17.8	11.0	NMTR
1992	1	2	-103.19	32.30			1.80	M	17.8	11.0	NMTR
1992	1	3	-103.19	32.30			1.90	M	17.8	11.0	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1992	1	4	-103.19	32.30			1.50	M	17.8	11.0	NMTR
1992	1	7	-103.19	32.30			2.40	M	17.8	11.0	NMTR
1992	1	9	-103.19	32.30			2.80	M	17.8	11.0	NMTR
1992	1	11	-103.19	32.30			2.00	M	17.8	11.0	NMTR
1992	1	23	-102.29	31.84			1.90	M	99.2	61.7	NMTR
1992	2	2	-102.86	32.17			1.90	M	36.4	22.6	NMTR
1992	3	15	-104.12	34.92			1.70	M	292.1	181.5	NMTR
1992	3	28	-105.39	33.45			1.80	M	242.2	150.5	NMTR
1992	4	3	-103.03	32.26			2.10	M	19.9	12.4	NMTR
1992	4	6	-102.61	31.86			1.70	M	77.7	48.3	NMTR
1992	4	7	-102.29	31.56			1.60	M	122.6	76.2	NMTR
1992	4	7	-102.29	31.56			2.30	M	122.6	76.2	NMTR
1992	4	7	-102.29	31.56			1.70	M	122.6	76.2	NMTR
1992	4	8	-104.86	32.41			1.60	M	166.9	103.7	NMTR
1992	4	30	-104.31	30.66			1.70	M	229.0	142.3	NMTR
1992	5	9	-104.34	30.49			1.60	M	246.7	153.3	NMTR
1992	5	15	-103.08	32.28			1.60	M	17.5	10.9	NMTR
1992	5	16	-102.34	31.75			1.70	M	103.0	64.0	NMTR
1992	6	14	-103.10	32.30			2.30	M	15.1	9.4	NMTR
1992	6	20	-102.42	31.43			1.60	M	127.5	79.2	NMTR
1992	6	20	-102.42	31.43			1.50	M	127.5	79.2	NMTR
1992	6	29	-102.47	31.42			1.40	M	126.9	78.8	NMTR
1992	6	29	-102.47	31.42			1.40	M	126.9	78.8	NMTR
1992	6	29	-102.47	31.42			2.00	M	126.9	78.8	NMTR
1992	7	5	-102.39	31.88			1.50	M	89.4	55.6	NMTR
1992	7	5	-102.39	31.88			1.30	M	89.4	55.6	NMTR
1992	7	21	-103.13	32.28			1.90	M	17.8	11.1	NMTR
1992	8	12	-102.41	31.39			1.50	M	131.9	82.0	NMTR
1992	8	18	-102.45	31.46			1.90	M	123.5	76.7	NMTR
1992	8	19	-100.92	33.11			2.20	M	215.3	133.8	NMTR
1992	8	26	-102.71	32.17	5.0	3.1	3.00	un	45.6	28.4	ANSS
1992	8	28	-100.98	32.38			1.70	M	197.4	122.6	NMTR
1992	9	4	-102.26	31.42			1.90	M	136.8	85.0	NMTR
1992	9	15	-103.02	32.16			2.20	M	31.6	19.6	NMTR
1992	10	8	-102.81	32.25			1.60	M	33.1	20.6	NMTR
1992	10	10	-102.41	31.71			1.60	M	102.2	63.5	NMTR
1992	10	27	-101.93	34.12			1.30	M	215.1	133.7	NMTR
1992	11	22	-103.16	32.29			1.70	M	18.0	11.2	NMTR
1992	11	27	-102.49	31.44			1.30	M	124.0	77.1	NMTR
1992	12	2	-102.35	31.42			2.40	M	131.5	81.7	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1992	12	3	-103.74	33.66			1.90	M	149.6	93.0	NMTR
1992	12	5	-102.51	31.87			1.40	M	83.0	51.6	NMTR
1993	1	4	-105.27	31.06			1.30	M	256.5	159.4	NMTR
1993	1	28	-102.58	31.85			1.80	M	80.3	49.9	NMTR
1993	1	31	-104.64	30.60			1.50	M	250.8	155.9	NMTR
1993	2	11	-105.23	31.12			2.00	M	250.1	155.4	NMTR
1993	2	28	-102.43	31.21			1.30	M	149.4	92.8	NMTR
1993	2	28	-102.41	31.22			1.50	M	149.3	92.8	NMTR
1993	3	8	-103.33	30.87			1.60	M	175.9	109.3	NMTR
1993	3	21	-102.37	31.43			1.50	M	130.4	81.0	NMTR
1993	4	23	-102.47	31.21			1.70	M	147.8	91.9	NMTR
1993	5	5	-105.16	32.29			2.10	M	195.3	121.4	NMTR
1993	5	16	-105.06	30.44			2.20	M	290.1	180.2	NMTR
1993	5	17	-102.33	31.42			2.30	M	133.3	82.9	NMTR
1993	5	23	-102.42	31.42			1.60	M	128.7	80.0	NMTR
1993	5	28	-103.12	32.75			2.50	M	34.6	21.5	NMTR
1993	6	17	-102.56	31.80			1.70	M	86.5	53.8	NMTR
1993	6	23	-102.44	31.51			1.40	M	119.5	74.2	NMTR
1993	6	23	-102.54	31.43			2.50	M	123.2	76.6	NMTR
1993	6	23	-102.52	31.43			2.80	M	123.2	76.5	NMTR
1993	6	23	-102.52	31.43			2.10	M	123.2	76.5	NMTR
1993	6	23	-102.54	29.66			1.90	M	312.3	194.0	NMTR
1993	6	23	-102.51	31.35	5.0	3.1	2.80	un	132.5	82.3	ANSS
1993	6	24	-102.45	31.48			2.10	M	121.9	75.7	NMTR
1993	7	3	-102.43	31.44			1.50	M	126.7	78.7	NMTR
1993	7	3	-102.34	31.50			2.20	M	125.5	78.0	NMTR
1993	7	3	-102.38	31.54			1.60	M	119.3	74.1	NMTR
1993	8	13	-102.52	31.89			1.30	M	80.1	49.8	NMTR
1993	8	29	-102.91	32.35			2.50	M	19.0	11.8	NMTR
1993	9	5	-100.96	32.28			2.00	M	200.1	124.4	NMTR
1993	9	6	-100.91	32.48			1.80	M	203.6	126.5	NMTR
1993	9	11	-103.76	34.72			1.50	M	260.9	162.1	NMTR
1993	9	26	-103.52	35.08			1.50	M	296.6	184.3	NMTR
1993	9	30	-103.80	33.64			1.90	M	149.0	92.6	NMTR
1993	10	3	-103.84	33.61			1.70	M	148.5	92.3	NMTR
1993	11	6	-102.19	31.75			1.50	M	113.6	70.6	NMTR
1993	11	24	-104.74	32.34			1.30	M	156.2	97.1	NMTR
1993	11	25	-102.10	34.27			2.60	M	223.0	138.5	NMTR
1993	11	25	-104.38	30.49			1.30	M	248.6	154.5	NMTR
1993	12	2	-102.34	31.27			1.30	M	147.3	91.5	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1993	12	3	-102.23	31.68			1.60	M	115.6	71.8	NMTR
1993	12	10	-102.29	31.74			1.60	M	106.8	66.4	NMTR
1993	12	18	-103.41	30.21			1.80	M	249.5	155.0	NMTR
1993	12	22	-105.68	33.33	10.0	6.2	3.20	un	261.9	162.8	ANSS
1994	1	6	-105.09	31.95			2.40	M	196.3	122.0	NMTR
1994	1	7	-102.32	31.24			1.70	M	151.0	93.8	NMTR
1994	3	15	-103.56	30.11			2.00	M	261.9	162.8	NMTR
1994	4	21	-103.12	32.31			1.40	M	14.1	8.8	NMTR
1994	4	25	-104.62	30.60			1.90	M	250.5	155.7	NMTR
1994	5	23	-102.64	32.11			1.60	M	55.0	34.2	NMTR
1994	6	30	-102.33	31.36			1.30	M	138.6	86.2	NMTR
1994	8	22	-102.21	33.34			1.60	M	129.0	80.2	NMTR
1994	8	30	-102.32	31.38			1.40	M	137.3	85.3	NMTR
1994	8	30	-102.32	31.34			1.50	M	141.5	87.9	NMTR
1994	8	30	-102.30	31.42			1.30	M	135.1	84.0	NMTR
1994	9	24	-102.36	31.43			2.00	M	131.1	81.4	NMTR
1994	11	24	-100.80	32.39			2.70	M	214.3	133.2	NMTR
1995	1	1	-102.45	31.77			1.40	M	94.7	58.8	NMTR
1995	1	4	-102.38	31.48			1.30	M	125.0	77.6	NMTR
1995	2	1	-104.09	34.51			1.80	M	248.7	154.6	NMTR
1995	3	19	-104.21	35.00	5.0	3.1	3.30	un	303.1	188.4	ANSS
1995	4	14	-103.35	30.28			5.70	M	240.7	149.5	UTIG
1995	4	18	-102.27	31.44			1.90	M	134.5	83.6	NMTR
1995	4	18	-105.34	31.10			1.60	M	259.8	161.4	NMTR
1995	4	21	-103.35	30.30	10.0	6.2	2.90	un	238.5	148.2	ANSS
1995	5	11	-105.20	32.71			2.40	M	200.4	124.5	NMTR
1995	5	15	-102.42	31.40			1.80	M	131.1	81.5	NMTR
1995	5	27	-102.34	31.34			2.30	M	140.1	87.0	NMTR
1995	5	30	-105.21	32.71			2.10	M	200.9	124.8	NMTR
1995	7	11	-105.06	30.87			1.80	M	255.5	158.8	NMTR
1995	7	17	-104.94	31.15			1.40	M	226.0	140.4	NMTR
1995	8	1	-105.27	33.14			1.30	M	218.9	136.0	NMTR
1995	8	2	-103.36	30.31			1.80	M	237.2	147.4	NMTR
1995	8	12	-103.07	30.79			1.90	M	183.1	113.8	NMTR
1995	8	14	-102.96	30.41			1.50	M	225.3	140.0	NMTR
1995	10	19	-104.84	32.05			2.00	M	170.4	105.9	NMTR
1995	10	25	-103.42	30.35			2.20	M	233.6	145.2	NMTR
1995	11	12	-103.35	30.30	10.0	6.2	3.60	ML	238.5	148.2	ANSS
1995	12	3	-104.90	31.93			1.50	M	180.1	111.9	NMTR
1995	12	4	-104.90	31.93			1.40	M	180.1	111.9	NMTR

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1995	12	4	-104.90	31.93			1.30	M	180.1	111.9	NMTR
1996	3	15	-105.69	33.59	10.0	6.2	2.90	ML	274.6	170.6	ANSS
1998	4	15	-103.30	30.19	10.0	6.2	3.60	ML	250.4	155.6	ANSS
1999	3	1	-104.66	32.57	1.0	0.6	2.90	ML	148.1	92.0	ANSS
1999	3	14	-104.63	32.59	1.0	0.6	4.00	ML	145.9	90.7	ANSS
1999	3	17	-104.67	32.58	1.0	0.6	3.50	Mc	149.7	93.0	ANSS
1999	5	30	-104.66	32.58	10.0	6.2	3.90	ML	148.9	92.5	ANSS
1999	8	9	-104.59	32.57	5.0	3.1	2.90	Mc	142.0	88.3	ANSS
2000	2	2	-104.63	32.58	5.0	3.1	2.70	ML	145.7	90.5	ANSS
2000	2	26	-103.61	30.24	5.0	3.1	2.80	ML	248.6	154.5	ANSS
2001	6	2	-103.14	32.33	5.0	3.1	3.30	ML	12.6	7.8	ANSS
2001	11	22	-102.63	31.79	5.0	3.1	3.10	ML	83.7	52.0	ANSS
2002	9	17	-104.63	32.58	10.0	6.2	3.50	ML	145.8	90.6	ANSS
2002	9	17	-104.63	32.58	10.0	6.2	3.30	ML	145.8	90.6	ANSS
2003	6	21	-104.51	32.67	5.0	3.1	3.60	ML	135.5	84.2	ANSS

Notes:

Focal depth information only available for events reported in ANSS Catalog

[2] MAG - Magnitude

[3] MAG Type

- M – Moment Magnitude
- mb – Body – wave Magnitude
- un – Unspecified Magnitude
- ML – Local Magnitude
- Mc – Coda – wave Magnitude

[4] Data Sources

- UTIG – University of Texas Institute for Geophysics
- NMTH – New Mexico Tech Historical Catalog
- NMTR – New Mexico Tech Regional Catalog, Exclusive of Socorro NM Events
- ANSS – Advanced National Seismic System

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1931	8	16	-104.60	30.70			6.00	M	240.3	149.3	UTIG
1949	5	23	-105.20	34.60			4.50	M	310.0	192.6	NMTH
1955	1	27	-104.50	30.60			3.30	M	244.0	151.6	UTIG
1962	3	6	-104.80	31.20			3.50	M	212.3	131.9	UTIG
1963	12	19	-104.27	34.82			3.40	M	287.0	178.3	NMTR
1964	11	8	-103.10	31.90			3.00	M	59.5	37.0	UTIG
1964	11	21	-103.10	31.90			3.10	M	59.5	37.0	UTIG
1965	2	3	-103.10	31.90			3.30	M	59.5	37.0	UTIG
1965	8	30	-103.00	31.90			3.50	M	60.0	37.3	UTIG
1966	8	14	-103.00	31.90			3.40	M	60.0	37.3	UTIG
1966	11	26	-105.44	30.95			3.50	M	277.5	172.4	NMTR
1971	7	30	-103.00	31.72	10.0	6.2	3.00	mb	79.9	49.6	ANSS
1971	7	31	-103.06	31.70	10.0	6.2	3.40	mb	81.4	50.6	ANSS
1971	9	24	-103.20	31.60			3.20	M	93.5	58.1	UTIG
1972	7	26	-104.01	32.57			3.10	M	88.3	54.9	NMTR
1973	8	2	-105.56	31.04			3.60	M	280.7	174.5	NMTR
1973	8	4	-103.22	35.11			3.00	M	296.6	184.3	NMTR
1974	11	28	-104.14	32.31	5.0	3.1	3.90	mb	100.4	62.4	ANSS
1974	12	30	-103.10	30.90			3.70	M	170.5	106.0	UTIG
1975	2	2	-103.19	35.05			3.00	M	290.7	180.6	NMTR
1975	8	1	-104.00	31.40			3.00	M	143.9	89.4	UTIG
1975	12	12	-102.31	31.61			3.00	M	117.5	73.0	NMTR
1976	1	19	-103.09	31.90			3.50	M	59.5	37.0	UTIG
1976	1	25	-103.08	31.90	2.0	1.2	3.90	un	59.3	36.8	ANSS
1976	8	5	-103.00	31.60			3.00	M	93.1	57.9	UTIG
1976	9	17	-102.50	31.40			3.10	M	127.4	79.2	UTIG
1977	4	26	-103.08	31.90	4.0	2.5	3.30	un	59.3	36.8	ANSS
1977	6	7	-100.75	33.06	5.0	3.1	4.00	un	228.5	142.0	ANSS
1977	7	22	-102.70	31.80			3.00	M	79.2	49.2	UTIG
1977	11	28	-100.84	32.95	5.0	3.1	3.50	un	217.4	135.1	ANSS
1978	3	2	-102.38	31.58			3.30	M	115.4	71.7	NMTR
1978	3	2	-102.56	31.55			3.50	M	109.9	68.3	UTIG
1978	6	16	-100.80	33.00			3.40	M	222.1	138.0	UTIG
1978	6	16	-100.77	33.03	10.0	6.2	5.30	un	226.1	140.5	ANSS
1978	6	29	-102.42	31.08			3.20	M	163.1	101.4	NMTR
1982	1	4	-102.49	31.18	5.0	3.1	3.90	un	149.9	93.2	ANSS
1982	11	28	-100.84	33.00	5.0	3.1	3.30	un	218.4	135.7	ANSS
1983	9	15	-104.43	34.92			3.10	M	302.6	188.1	NMTR
1984	5	21	-102.23	35.07	5.0	3.1	3.10	un	302.5	188.0	ANSS
1984	9	11	-100.70	31.99	5.0	3.1	3.20	un	229.4	142.5	ANSS

Table 3.2-20 Location of Recorded Earthquakes Within a 322 km (200 mi) Radius of the NEF Site

NEF Site Coordinates			Longitude -103.0820	Latitude 32.4360							
Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal (km)	Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
1984	9	19	-100.69	32.03	5.0	3.1	3.00	un	229.3	142.5	ANSS
1986	1	30	-100.69	32.07	5.0	3.1	3.30	un	228.0	141.7	ANSS
1990	8	3	-100.69	32.21			3.40	M	225.6	140.2	NMTR
1992	1	2	-103.19	32.30			5.00	M	17.8	11.0	NMTR
1992	8	26	-102.71	32.17	5.0	3.1	3.00	un	45.6	28.4	ANSS
1993	12	22	-105.68	33.33	10.0	6.2	3.20	un	261.9	162.8	ANSS
1995	3	19	-104.21	35.00	5.0	3.1	3.30	un	303.1	188.4	ANSS
1995	4	14	-103.35	30.28			5.70	M	240.7	149.5	UTIG
1995	11	12	-103.35	30.30	10.0	6.2	3.60	ML	238.5	148.2	ANSS
1998	4	15	-103.30	30.19	10.0	6.2	3.60	ML	250.4	155.6	ANSS
1999	3	14	-104.63	32.59	1.0	0.6	4.00	ML	145.9	90.7	ANSS
1999	3	17	-104.67	32.58	1.0	0.6	3.50	Mc	149.7	93.0	ANSS
1999	5	30	-104.66	32.58	10.0	6.2	3.90	ML	148.9	92.5	ANSS
2001	6	2	-103.14	32.33	5.0	3.1	3.30	ML	12.6	7.8	ANSS
2001	11	22	-102.63	31.79	5.0	3.1	3.10	ML	83.7	52.0	ANSS
2002	9	17	-104.63	32.58	10.0	6.2	3.50	ML	145.8	90.6	ANSS
2002	9	17	-104.63	32.58	10.0	6.2	3.30	ML	145.8	90.6	ANSS
2003	6	21	-104.51	32.67	5.0	3.1	3.60	ML	135.5	84.2	ANSS

Notes:

Focal depth information only available for events reported in ANSS Catalog

[2] MAG - Magnitude

[3] MAG Type
- M – Moment Magnitude
- mb – Body – wave Magnitude
- un – Unspecified Magnitude
- ML – Local Magnitude
- Mc – Coda – wave Magnitude

[4] Data Sources
- UTIG – University of Texas Institute for Geophysics
- NMTH – New Mexico Tech Historical Catalog
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- ANSS – Advanced National Seismic System

Table 3.2-22 Earthquake Data Sources for New Mexico and West Texas

Data Source	Time Span	Number of events in 322 km (200 mi) Radius
New Mexico Tech, Regional Catalog	1962 - 1995	504
New Mexico Tech, Historical Catalog	1869 - 1992	2
University of Texas Institute of Geophysics	1931 - 1998	42
Advanced National Seismic System	1962 - 2003	64

Table 3.2-23 Modified Mercalli Intensity Scale

Intensity Value	Description
I	Not felt except by a very few under especially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.
V	Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown in the air.

Table 3.2-24 Comparison of Parameters for the January 2, 1992 Eunice, New Mexico Earthquake

Year	Month	Day	Longitude	Latitude	Magnitude	Data Source[1]
1992	1	2	-103.1863	32.3025	5.0	NMTR
1992	1	2	-102.97	32.36	4.6	UTIG
1992	1	2	-103.2	32.3	5.0	NMTH
1992	1	2	-103.101	32.336	5.0	ANSS

[1]Data Sources:

UTIG University of Texas Institute for Geophysics

NMTH New Mexico Tech Historical Catalog

ANSS Advanced National Seismic System

NMTR New Mexico Tech Regional Catalog, exclusive of Socorro New Mexico events

Table 3.2-25 Earthquake Recurrence Models for the NEF Site Region

Earthquake Recurrence Models							
Zone		**Area (km^2)**	**a-value**	**b-value**	**Beta**	**Rate/yr M > = 5.0**	**Return Period M > = 5.0**
200 Mile Radius	253,502	best fit	2.15	-0.74	-1.704	0.0282	35
		fixed b, -0.9	2.80	-0.90	-2.072	0.0200	50
Region 1 – 100 Mile Radius	78,758	best fit	2.25	-0.89	-2.049	0.0063	158
		fixed b, -0.9	2.40	-0.90	-2.072	0.0079	126
Central Basin Earthquake Cluster	15,065	best fit	1.98	-0.86	-1.980	0.0048	209
		fixed b, -0.9	2.20	-0.90	-2.072	0.0050	200

Table 3.2-26 Earthquake Recurrence Models for the Central Basin Platform (CBP)in the Waste Isolation Pilot Project (WIPP) Safety Analysis Report (SAR)

WIPP SAR Earthquake Recurrence Models						
Zone	**Area (km^2)**	**a-value**	**b-value**	**Beta**	**Rate/yr M > = 5.0**	**Return Period M > = 5.0**
WIPP SAR						
Background	10,000 M uncorrected	1.439	-1.000	2.303	0.0003	3639
Background	10,000 M corrected	1.939	-1.000	2.303	0.0009	1151
Rio Grande Rift	110,000 M uncorrected	2.560	-1.000	2.303	0.0036	275
Rio Grande Rift	110,000 M corrected	3.060	-1.000	2.303	0.0115	87
Basin & Range Subregion	640,000 M uncorrected	2.750	-1.000	2.303	0.0056	178
Basin & Range Subregion	640,000 M corrected	3.250	-1.000	2.303	0.0178	56
WIPP Central Basin Platform	7,500 M uncorrected	2.740	-0.900	2.072	0.0174	58
WIPP Central Basin Platform	7,500 M corrected	3.190	-0.900	2.072	0.0490	20

Table 3.2-27 Attenuation Model Formulas and Coefficients

Model	Ground Motion Parameter (y)	c_1	c_2	c_3	c_4
EPRI NP-6074	psrv (1 Hz)	-7.95	2.14	-1.00	-0.0018
Hard Rock Site Condition	psrv (2.5 Hz)	-3.82	1.49	-1.00	-0.0024
$\sigma_{ln(y)} = 0.5$	psrv (5 Hz)	-2.11	1.20	-1.00	-0.0031
	psrv (10 Hz)	-1.55	1.05	-1.00	-0.0039
	psrv (25 Hz)	-1.63	0.98	-1.00	-0.0053
	PGA	2.55	1.00	-1.00	-0.0046
Equation:	$\ln(y) = c_1 + c_2 m_{Lg} + c_3 \ln(R) + c_4 R$				
Nuttli, 1986	psrv (1 Hz)†	0.29	1.15	-0.83	-0.0028
Firm Rock Site Condition	psrv (2.5 Hz)†	-0.62	1.15	-0.83	-0.0028
$\sigma_{ln(y)} = 0.5$	psrv (5 Hz)†	-1.32	1.15	-0.83	-0.0028
	psrv (10 Hz)†	-2.13	1.15	-0.83	-0.0028
	psrv (25 Hz)†	-3.53	1.15	-0.83	-0.0028
	PGA	1.38	1.15	-0.83	-0.0028
Equations:	**† For a given m_{Lg} and R, ln(y) is the smaller of:** $c_1 + c_2 m_{Lg} + c_3 \ln R + c_4 R$ and, $-8.3 + 2.3 m_{Lg} - 0.83 \ln(R) - 0.0012R$				

		c_1	c_2	c_3	c_4	c_5	c_6	c_7
Toro, 1997	Sa (0.5 Hz)	-0.74	1.86	-0.31	0.92	0.46	0.0017	6.9
Midcontinent,	Sa (1 Hz)	0.09	1.42	-0.20	0.90	0.49	0.0023	6.8
Moment magnitude scaling	Sa (2.5 Hz)	1.07	1.05	-0.10	0.93	0.56	0.0033	7.1
	Sa (5 Hz)	1.73	0.84	0	0.98	0.66	0.0042	7.5
	Sa (10 Hz)	2.37	0.81	0	1.10	1.02	0.0040	8.3
	Sa (25 Hz)	3.68	0.80	0	1.46	1.77	0.0013	10.5
	Sa (35 Hz)	4.00	0.79	0	1.57	1.83	0.0008	11.1
	PGA	2.20	0.81	0	1.27	1.16	0.0021	9.3
Equations:	$\ln(y) = c_1 + c_2(M-6) + c_3(M-6)^2 - c_4 \ln(R_M) - (c_5-c_4)\max[\ln(R_M/100),0] - c_6 R_M + \varepsilon_U + \varepsilon_r$ $R_M = (R^2 + c_7^2)^{1/2}$							

Note: psrv = pseudo relative velocity at given frequency
PGA = peak ground acceleration
Sa = Spectral acceleration at given frequency

Table 3.2-28 Seismic Hazard Results at NEF Site From Rio Grande Rift Seismic Source Zones

cm/s^2	(g)	WIPP Basin and Range	WIPP Rio Grande Rift	WIPP M corr Basin and Range	WIPP M corr Rio Grande Rift
peak ground accel.		Annual probability of PGA being exceeded			
4.94	0.005	4.45E-03	2.78E-03		
9.81	0.010	2.29E-03	1.35E-03	7.26E-03	4.31E-03
49.01	0.050	4.84E-05	2.42E-05	1.54E-04	7.74E-05
73.55	0.075	1.08E-05	5.09E-06	3.44E-05	1.63E-05
98.10	0.100	3.13E-06	1.39E-06	9.95E-06	4.46E-06
122.61	0.125	1.06E-06	4.52E-07	3.38E-06	1.45E-06
147.08	0.150	4.05E-07	1.65E-07	1.29E-06	5.28E-07
196.17	0.200	7.41E-08	2.81E-08	2.36E-07	8.98E-08
245.18	0.250	1.70E-08	6.08E-09	5.40E-08	1.94E-08
294.12	0.300	4.59E-09	1.56E-09	1.46E-08	4.98E-09
392.29	0.400	4.68E-10	1.46E-10	1.49E-09	4.67E-10
490.29	0.500	6.61E-11	1.92E-11	2.10E-10	6.14E-11

Table 3.2-29 Seismic Hazard Results at NEF Site From Local Source Zones

PGA (g)	B100B9W Mx=6.0	B100BFW Mx=6.0	B200B9W Mx=6.5	B200BFW Mx=6.5	Bk53B9W Mx=5.25	Bk53BFW Mx=5.25	B260B9W Mx=6.0	B260BFW Mx=6.0	Bk53B9T Mx=5.25	Bk53BFT Mx=5.25	B260B9T Mx-=6.0	B260BFT Mx=6.0	Weighted Average
Annual Probability of PGA Being Exceeded													
0.010	8.09E-03	7.21E-03	1.32E-02	1.91E-02	7.66E-03	6.83E-03	1.26E-02	1.81E-02	4.97E-03	4.45E-03	4.72E-03	6.87E-03	8.88E-03
0.050	1.69E-03	1.54E-03	1.27E-03	1.99E-03	1.09E-03	9.93E-04	9.74E-04	1.45E-03	5.65E-04	5.15E-04	4.18E-04	6.17E-04	1.01E-03
0.075	8.30E-04	7.60E-04	5.61E-04	8.88E-04	4.99E-04	4.55E-04	4.20E-04	6.26E-04	2.67E-04	2.43E-04	2.00E-04	2.97E-04	4.62E-04
0.100	4.75E-04	4.36E-04	3.07E-04	4.87E-04	2.69E-04	2.46E-04	2.26E-04	3.38E-04	1.43E-04	1.31E-04	1.13E-04	1.68E-04	2.53E-04
0.125	2.97E-04	2.74E-04	1.88E-04	3.01E-04	1.58E-04	1.45E-04	1.37E-04	2.05E-04	8.21E-05	7.50E-05	6.97E-05	1.04E-04	1.52E-04
0.150	1.97E-04	1.82E-04	1.25E-04	2.00E-04	9.81E-05	8.97E-05	8.89E-05	1.34E-04	4.91E-05	4.49E-05	4.55E-05	6.85E-05	9.76E-05
0.200	9.59E-05	8.88E-05	6.25E-05	1.02E-04	4.12E-05	3.77E-05	4.25E-05	6.45E-05	1.90E-05	1.73E-05	2.15E-05	3.26E-05	4.44E-05
0.250	5.12E-05	4.75E-05	3.51E-05	5.77E-05	1.87E-05	1.71E-05	2.26E-05	3.45E-05	7.89E-06	7.21E-06	1.11E-05	1.70E-05	2.21E-05
0.300	2.91E-05	2.70E-05	2.12E-05	3.53E-05	8.93E-06	8.17E-06	1.28E-05	1.98E-05	3.44E-06	3.15E-06	6.04E-06	9.38E-06	1.17E-05
0.400	1.06E-05	9.84E-06	8.85E-06	1.51E-05	2.23E-06	2.04E-06	4.66E-06	7.29E-06	7.00E-07	6.39E-07	2.02E-06	3.20E-06	3.64E-06
0.500	4.32E-06	4.03E-06	4.20E-06	7.32E-06	5.87E-07	5.35E-07	1.89E-06	3.00E-06	1.40E-07	1.27E-07	7.53E-07	1.21E-06	1.23E-06

Notes:

PGA = Peak horizontal ground acceleration in firm rock
W = WIPP attenuation model; T = Toro et al. (1997) approx. model
Mx = Maximum magnitude

Table 3.2-30 Peak Acceleration Seismic Hazard Summary for the NEF Site

Seismic Source	250 – year earthquake PGA as % g	475 – year earthquake PGA as % g
Local seismic zones	2.4%	3.6%
Max. for Rio Grande Rift	1.0%	1.8%

Table 3.2-31 Deleted

Table 3.2-32 Horizontal Response Spectrum for 10,000-Year and Design Basis Earthquakes

Soil Class C, 5% Damping						
	10,000-Year Earthquake			Design Basis Earthquake		
Period	psrv	Sa	SD	psrv	Sa	SD
sec	cm/sec	g	mm	cm/sec	g	mm
0.01	0.236	0.151	0.004	0.252	0.161	0.00400
0.02	0.472	0.151	0.015	0.503	0.161	0.01601
0.04	1.418	0.227	0.090	1.418	0.227	0.09025
0.05	1.975	0.253	0.157	1.975	0.253	0.15717
0.08	3.935	0.315	0.501	4.027	0.322	0.51272
0.10	5.480	0.351	0.872	5.828	0.373	0.92761
0.20	10.804	0.346	3.439	13.181	0.422	4.19551
0.40	10.804	0.173	6.878	22.945	0.367	14.60725
0.50	10.773	0.138	8.573	24.675	0.226	27.46285
1.00	10.773	0.069	17.146	18.499	0.039	89.21916
2.00	5.308	0.017	16.897	13.615	0.022	86.67338

Soil Class C, 10% Damping						
	10,000-Year Earthquake			Design Basis Earthquake		
Period	psrv	Sa	SD	psrv	Sa	SD
sec	cm/sec	g	mm	cm/sec	g	mm
0.010	0.236	0.151	0.004	0.252	0.161	0.044
0.020	0.472	0.151	0.015	0.503	0.161	0.016
0.040	1.130	0.181	0.072	1.163	0.186	0.074
0.050	1.577	0.202	0.125	1.621	0.208	0.129
0.080	3.148	0.252	0.401	3.251	0.260	0.414
0.100	4.372	0.280	0.696	4.528	0.290	0.721
0.200	8.618	0.276	2.743	9.842	0.315	3.133
0.400	8.618	0.138	5.487	19.758	0.253	15.723
0.500	8.665	0.111	6.896	19.708	0.211	18.782
1.000	8.119	0.052	12.921	17.455	0.056	55.562
2.000	4.684	0.015	14.909	15.518	0.033	74.844

psrv - pseudo relative velocity
Sa = spectral acceleration
SD = spectral displacement

Table 3.2-33 Vertical Response Spectrum for 10,000-Year and Design Basis Earthquakes

Soil Class C, 5% Damping						
	10,000-Year Earthquake			Design Basis Earthquake		
Period	psrv	Sa	SD	psrv	Sa	SD
sec	cm/sec	g	mm	cm/sec	g	mm
0.01	0.157	0.101	0.003	0.168	0.107	0.003
0.02	0.314	0.101	0.001	0.335	0.107	0.011
0.04	0.945	0.151	0.060	0.945	0.151	0.060
0.05	1.317	0.169	0.105	1.317	0.169	0.105
0.08	2.623	0.210	0.334	2.685	0.215	0.342
0.10	3.653	0.234	0.581	3.886	0.249	0.618
0.20	7.203	0.231	2.293	8.787	0.281	2.797
0.40	7.203	0.115	4.585	15.297	0.245	9.738
0.50	7.182	0.092	5.715	16.450	0.151	18.309
1.00	7.182	0.046	11.431	12.333	0.026	59.479
2.00	3.539	0.011	11.265	9.076	0.015	57.782

Soil Class C, 10% Damping						
	10,000-Year Earthquake			Design Basis Earthquake		
Period	psrv	Sa	SD	psrv	Sa	SD
sec	cm/sec	g	mm	cm/sec	g	mm
0.010	0.157	0.101	0.003	0.168	0.107	0.003
0.020	0.314	0.101	0.010	0.335	0.107	0.011
0.040	0.754	0.121	0.048	0.775	0.124	0.049
0.050	1.051	0.135	0.084	1.081	0.138	0.086
0.080	2.098	0.168	0.267	2.168	0.174	0.276
0.100	2.914	0.187	0.464	3.019	0.193	0.480
0.200	5.746	0.184	1.829	6.562	0.210	2.089
0.400	5.746	0.092	3.658	13.172	0.169	10.482
0.500	5.777	0.074	4.597	13.139	0.141	12.521
1.000	5.413	0.035	8.614	11.637	0.037	37.042
2.000	3.123	0.010	9.940	10.346	0.022	49.896

psrv - pseudo relative velocity
Sa = spectral acceleration
SD = spectral displacement

3.2.10 Section 3.2 Figures

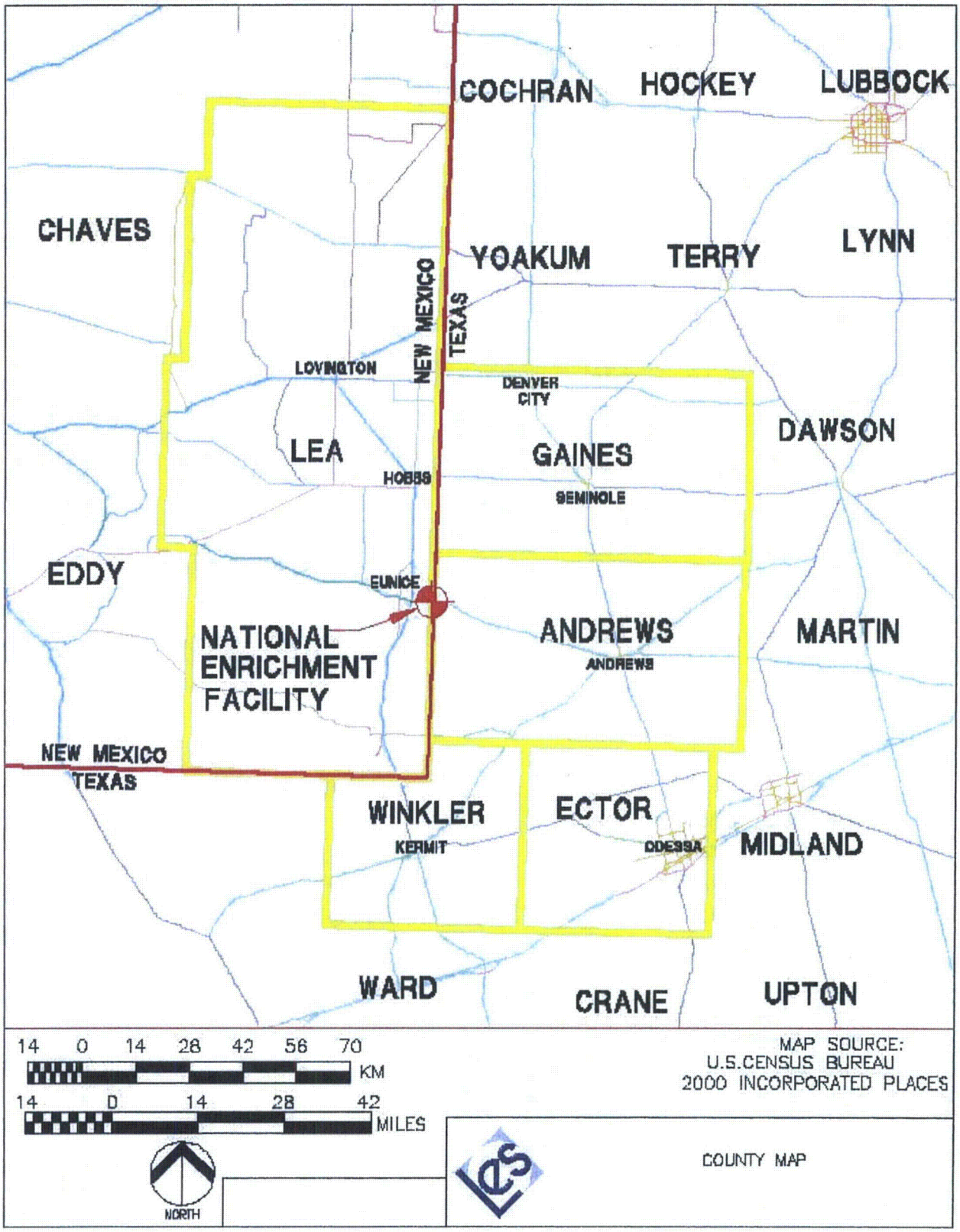


Figure 3.2-1 County Map

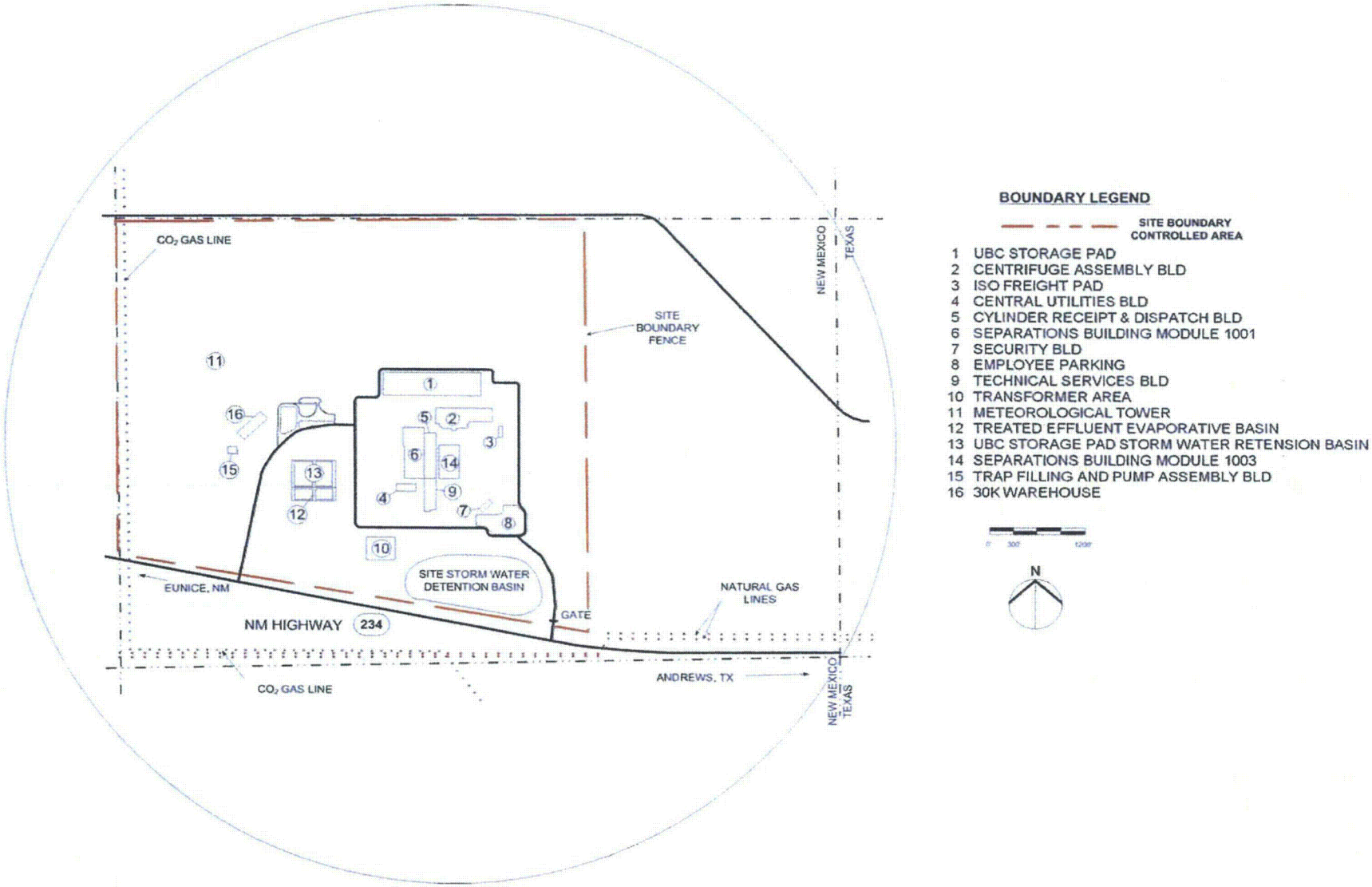


Figure 3.2-2 Plot Plan (1 Mile Radius)

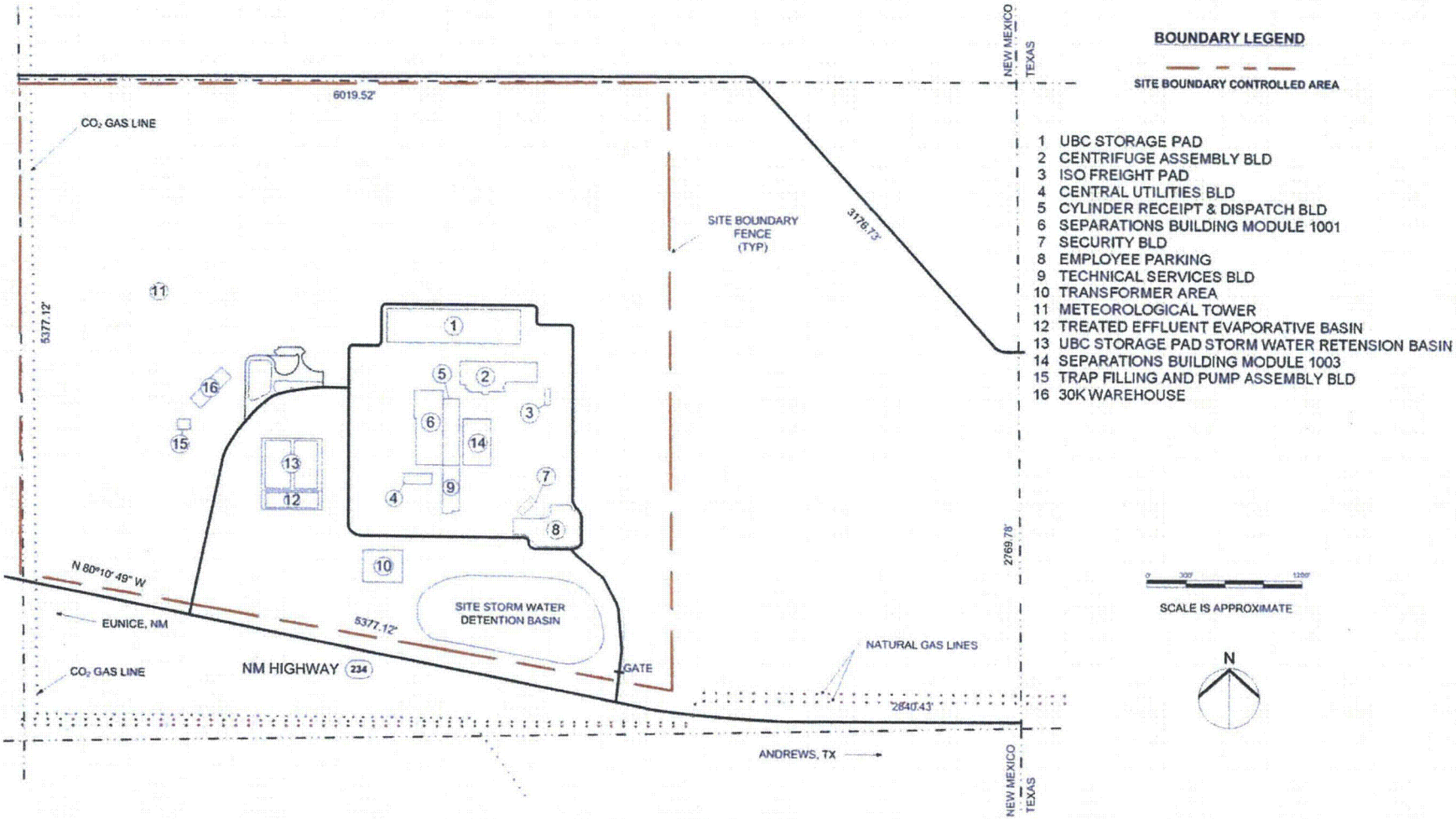
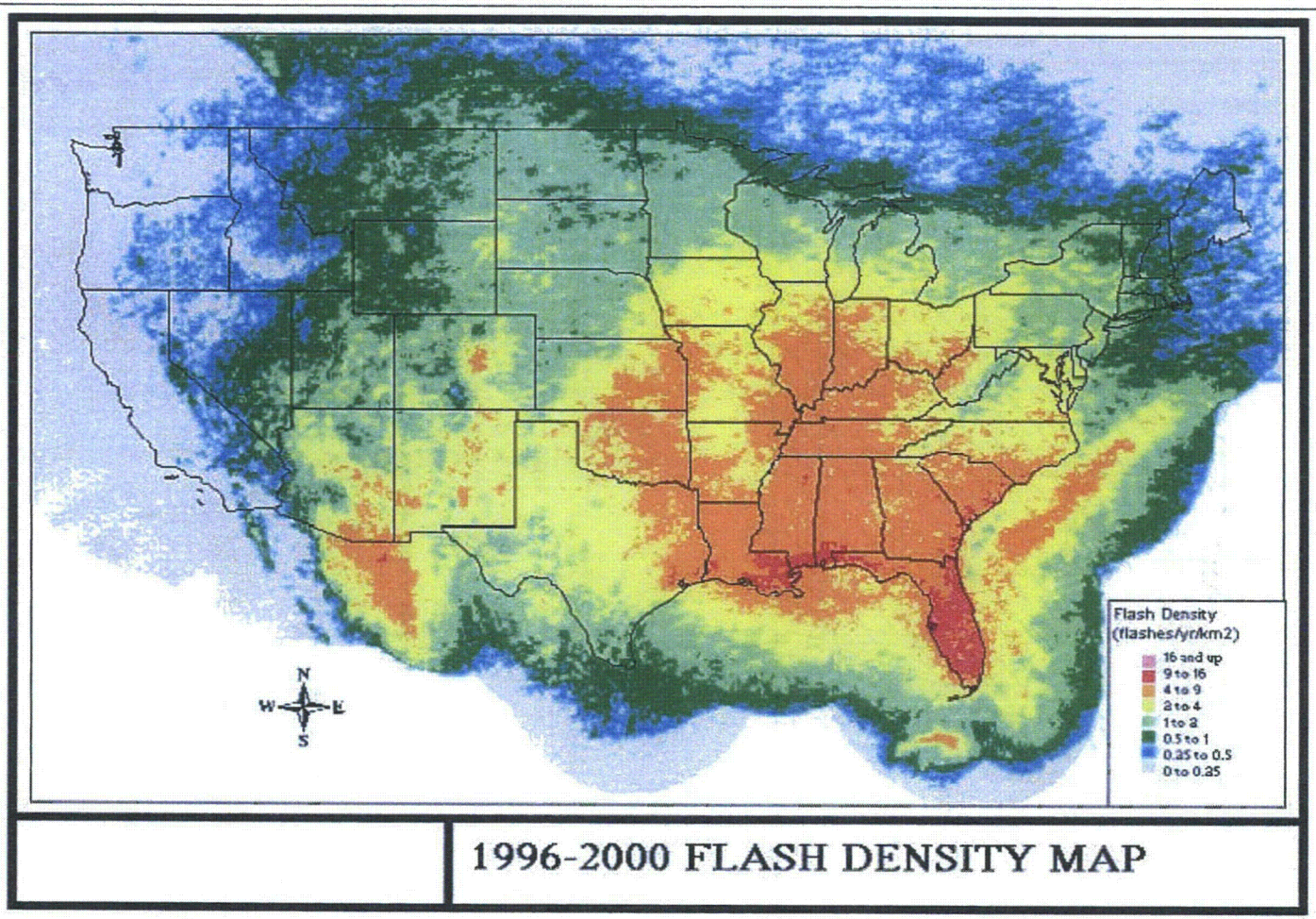


Figure 3.2-3 Site Plan



(NWS, 2003)

AVERAGE LIGHTNING FLASH DENSITY

Figure 3.2-4 Average Lightning Flash Density

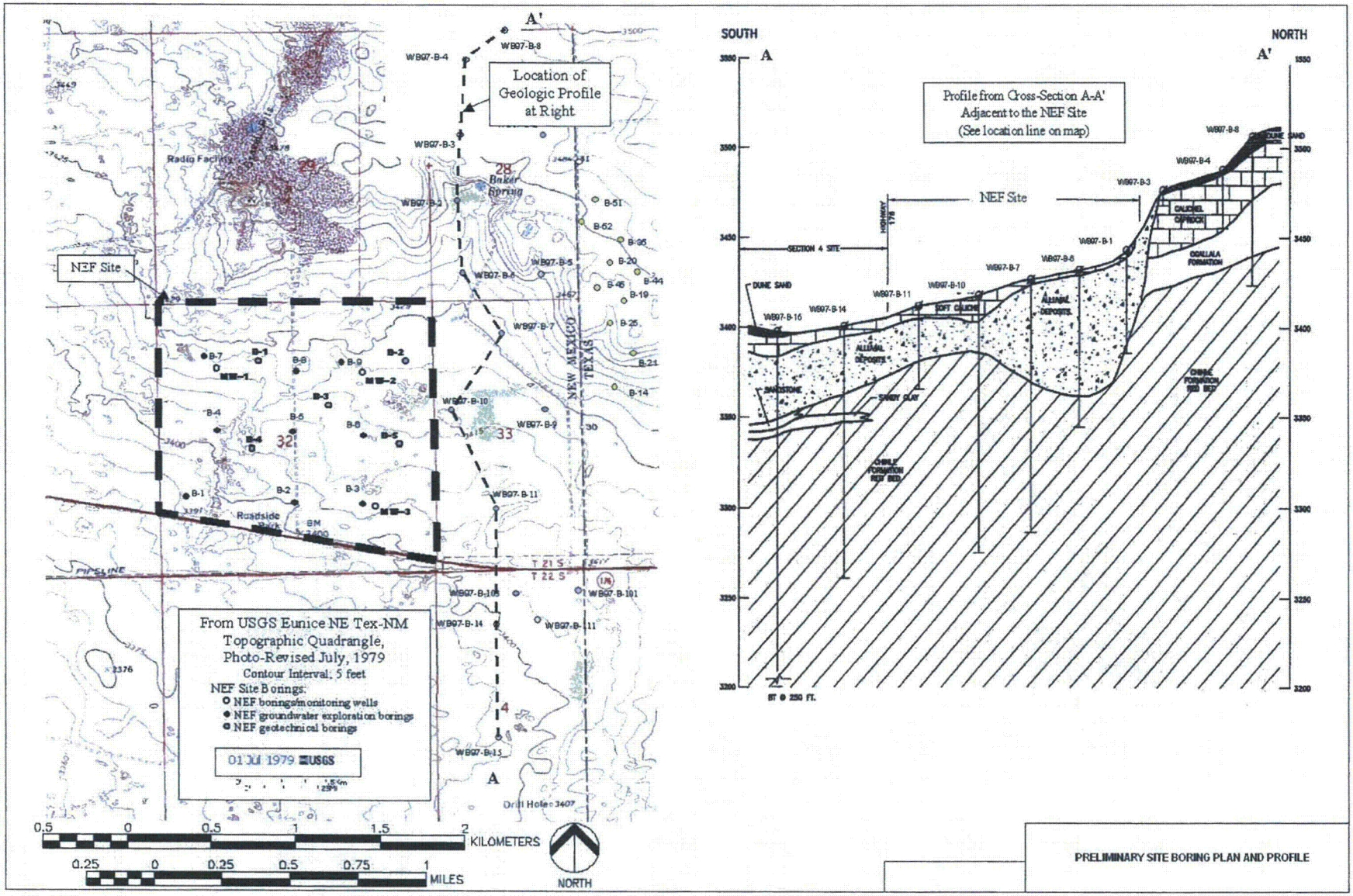
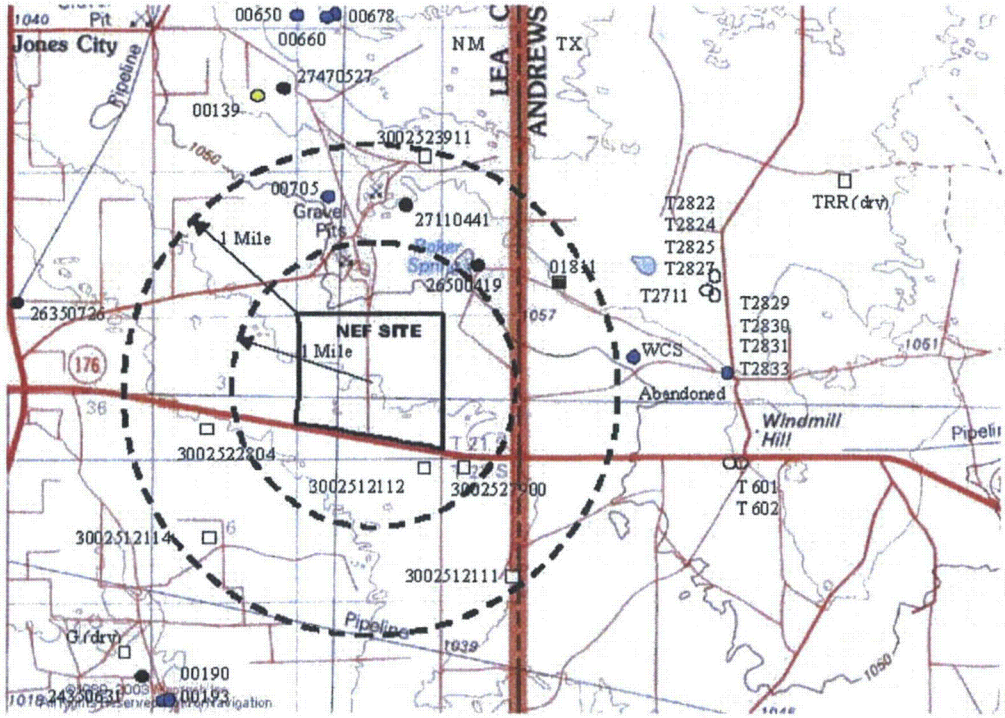


Figure 3.2-5 Preliminary Site Boring Plan and Profile

MONITORING WELLS		
WELL NO.	NORTHING	EASTING
MW-1	525569.74	925710.07
MW-2	525770.2	928625.73
MW-4	522326.995	929433.808
MW-5	524206.02	929825.78
MW-6	525881.706	929797.959
MW-7	527012.291	929741.526
MW-8	526979.997	928748.078
MW-9	526949.714	926975.341
MW-10	526974.82	926780.668
MW-11	526961.562	926251.803
MW-12	526950.295	925310.473
MW-13	526405.856	925022.698
MW-14	523292.982	924976.896
MW-15	522868.566	926358.939
MW-16	522675.427	927652.874
MW-17	526000.259	927162.85
MW-18	525246.462	925165.989
MW-19	525201.25	927581.17
MW-20	525147.25	927853.25
MW-21	525156.5	928228.42
MW-22	525154.92	928676.5
MW-23	524994.75	927653.83
MW-24	523744.58	926907.75
MW-25	523739.67	926739.67
MW-26	523747.17	926528.42

Figure 3.2-5A Monitoring Wells



Water Wells

- Undetermined
- Observation wells: USGS
- Livestock well
- Domestic Well

Oil Wells

- Open symbol represents dry, plugged and/or abandoned hole

1 0 1 2 3 4 KM

1 0.5 0 1 2 MILES

NORTH

WATER AND OIL WELLS
IN THE VICINITY OF THE NEF SITE

Figure 3.2-6 Water and Oil Wells in the Vicinity of the NEF Site

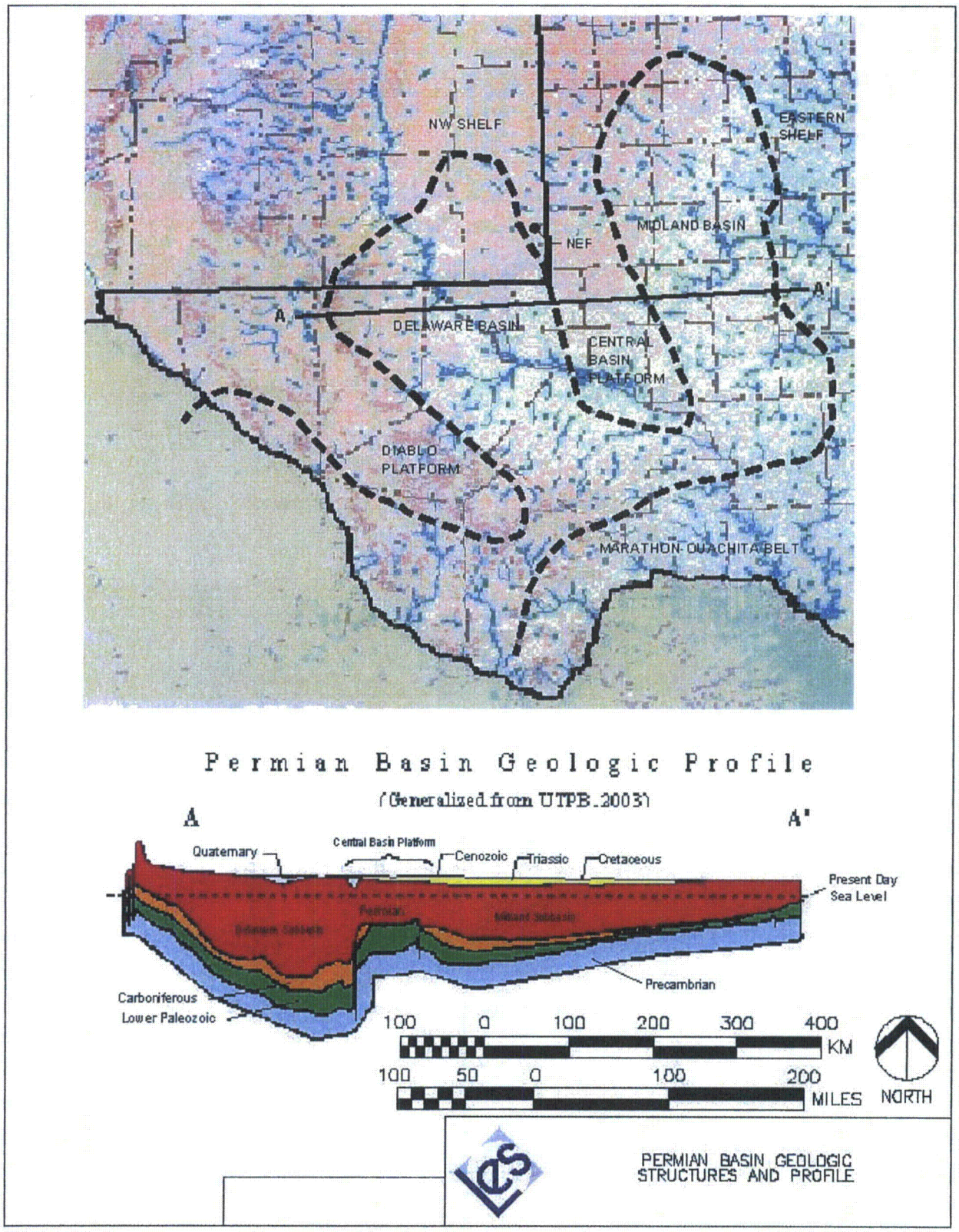


Figure 3.2-7 Permian Basin Geologic Structures and Profile

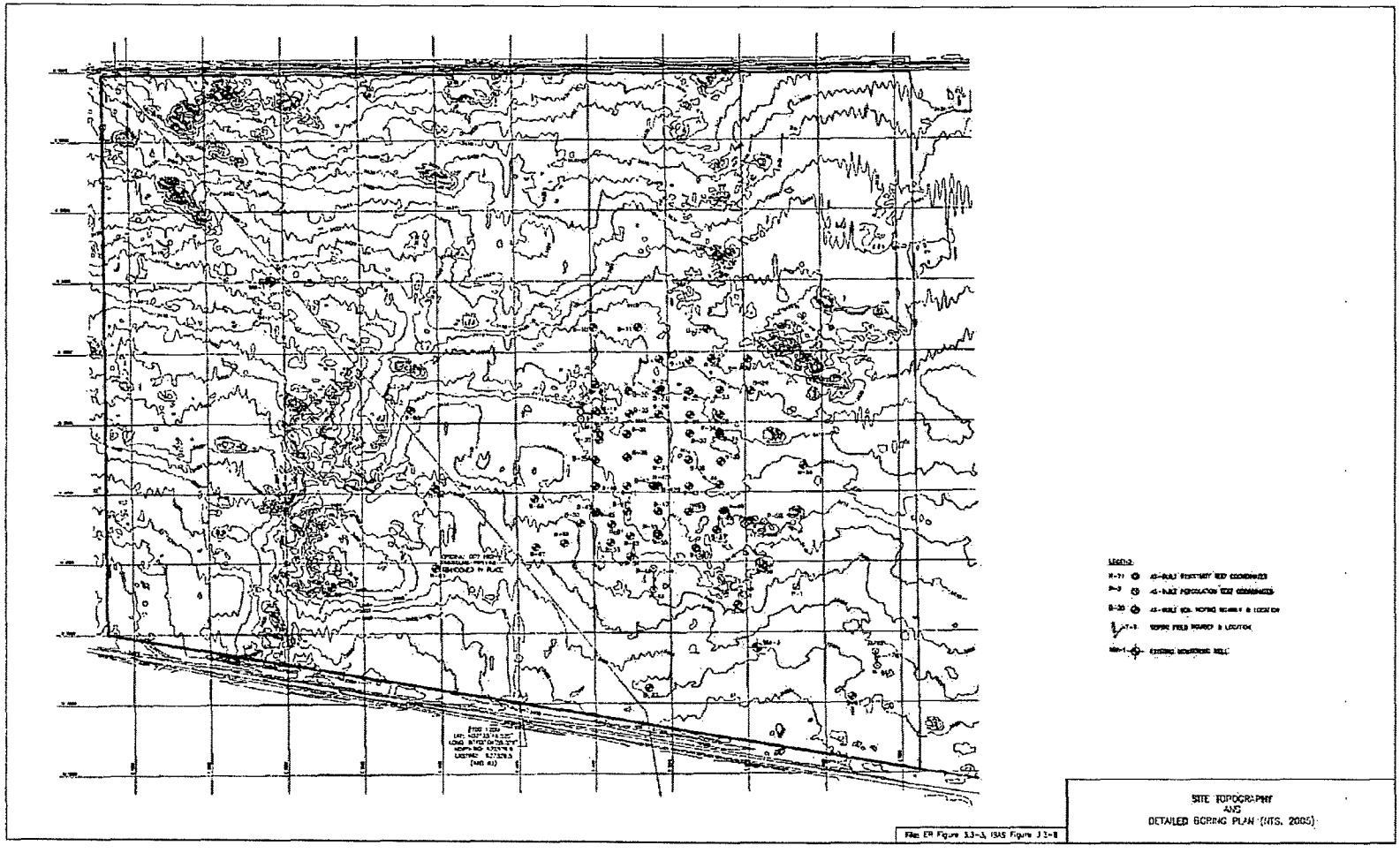


Figure 3.2-8 Site Topography

LEGEND

ca — CALICHE — *Partly indurated zone of calcium carbonate accumulation formed in upper layers of surficial deposits; 2 to 10 ft thick; commonly overlain by windblown sand. Much caliche shown on the map consists of tough, slabby surface layers underlain by calcium carbonate nodules that grade downward to fibers and veinlets. Especially well developed in Basin and Range and Great Plains parts of the state. Thick caliches (locally >20 ft) associated with undissected High Plains surfaces of the Great Plains commonly comprise an upper sequence of several carbonate-cemented zones interlayered with reddish loamy paleosol horizons over a basal caprock zone developed on Ogallala (To) sediments. Forms on various types of parent formations, indicated by subscripts. The extensive caliche along Rio Salado northwest of Socorro is partly a travertine deposit. Where buried by sand, the caliche is identified by subscript ca. A distinctive unit; boundaries are well defined where the caliche forms rimrock and approximate where exposed in deflation hollows. Where thick and well indurated, caliche is quarried for road metal and other aggregate, subject to minimal erosion*

al_2 — FLOODPLAIN AND CHANNEL DEPOSITS ALONG GENERALLY DRY ARROYOS AND WASHES — *Includes deposits along some perennial mountain streams. Extent exaggerated to emphasize drainage patterns. Sandier than al_1, gradients 5 to 15 percent. Arroyos 10 ft deep common. Surface flat where deposit was formed by stream overflowing its banks, hummocky where built of coalescing fans at mouths of tributaries that crowd the main stream against its far bank, or V-shaped where alluvium grades laterally into fan sand washed from adjoining hillsides. Ephemeral perched water tables under some deposits. Width of deposits represented has been exaggerated but total area probably about right because small deposits had to be omitted*

fs — SAND FACIES — *Sandy alluvium with subordinate amounts of fine gravel, silt, and clay. Forms at least four kinds of ground: 1) On short, steep fans sloping from the mountains of granitic or gneissic rock (e.g., parts of the Florida Mountains), this facies may form a smooth sandy layer a few feet thick covering gravel below; slopes 5 to 20 percent; washes 1 to 10 ft deep may expose underlying gravel. 2) On other short fans, sand facies may form arcuate belt at toe of fan with slopes averaging 10 percent, commonly reworked into coppice dunes 3 to 7 ft high (sm). 3) Other belts of smooth sandy ground commonly slope 5 percent or less and consist of sand mounds approximately 1 ft high over caliche (fs_2). 4) Gypsiferous sand (fs_3), especially in the Jornada del Muerto, Tularosa Valley and east side of the Pecos Valley. Sand facies absent on the broad Las Palomas surface. Thin fan sand covering pediments is denoted by fs over subscript that identifies underlying formation. Boundary with residual sand, fan gravel, and fan silt is approximate*

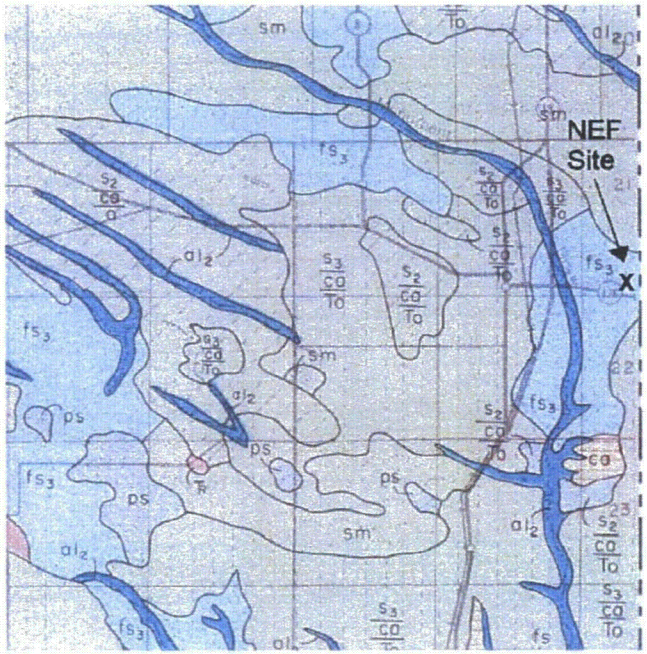
s_2/ca/To — MODERATELY THICK SAND ON CALICHE ON OGALLALA FORMATION — *Sand 1 to 3 ft thick. Surface layers noncalcareous over reddish loam. Local sand mounds. Ground favored for farming. Boundaries approximate*

s_3/ca/To — THICK SAND ON CALICHE ON OGALLALA FORMATION — *Sand 3 to 5 ft thick. Local mounds. Brownish-red, fine sandy loam over reddish-brown, sandy clay loam; noncalcareous to depths of 3 ft; calcareous subsoil contains filaments of lime carbonate. Where farmed, ground is subject to wind erosion. Boundaries approximate*

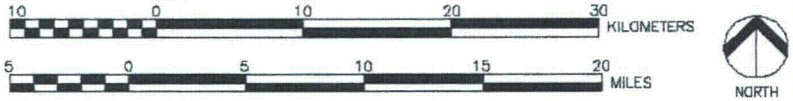
sm — LOOSE SAND IN MOUNDS — *Coppice dunes, commonly 3 to 7 ft high and 25 to 50 ft in diameter; generally elongated north of east but a local exception lies east of Columbus where elongation is south of east. Age is Holocene. Boundaries fairly accurate*

ps — SANDY LAKE OR PLAYA DEPOSITS — *Gypsiferous deposits labeled ps_2*

R — OTHER BEDROCK — *Colluvium or other cover amounts to less than half the area. Only extensive areas are shown; age and rock type keyed by symbol to State geologic map (e.g., Kd, Cretaceous Dakota Sandstone, Ŧs, Triassic Santa Rosa Sandstone). Many small areas omitted; indicated boundaries are approximate.* Ŧ – Triassic, undifferentiated



REFERENCE: (NMIMT, 1977)



SURFICIAL GEOLOGIC MAP OF THE NEF SITE AREA

Figure 3.2-9 Surficial Geologic Map of the NEF Site Area

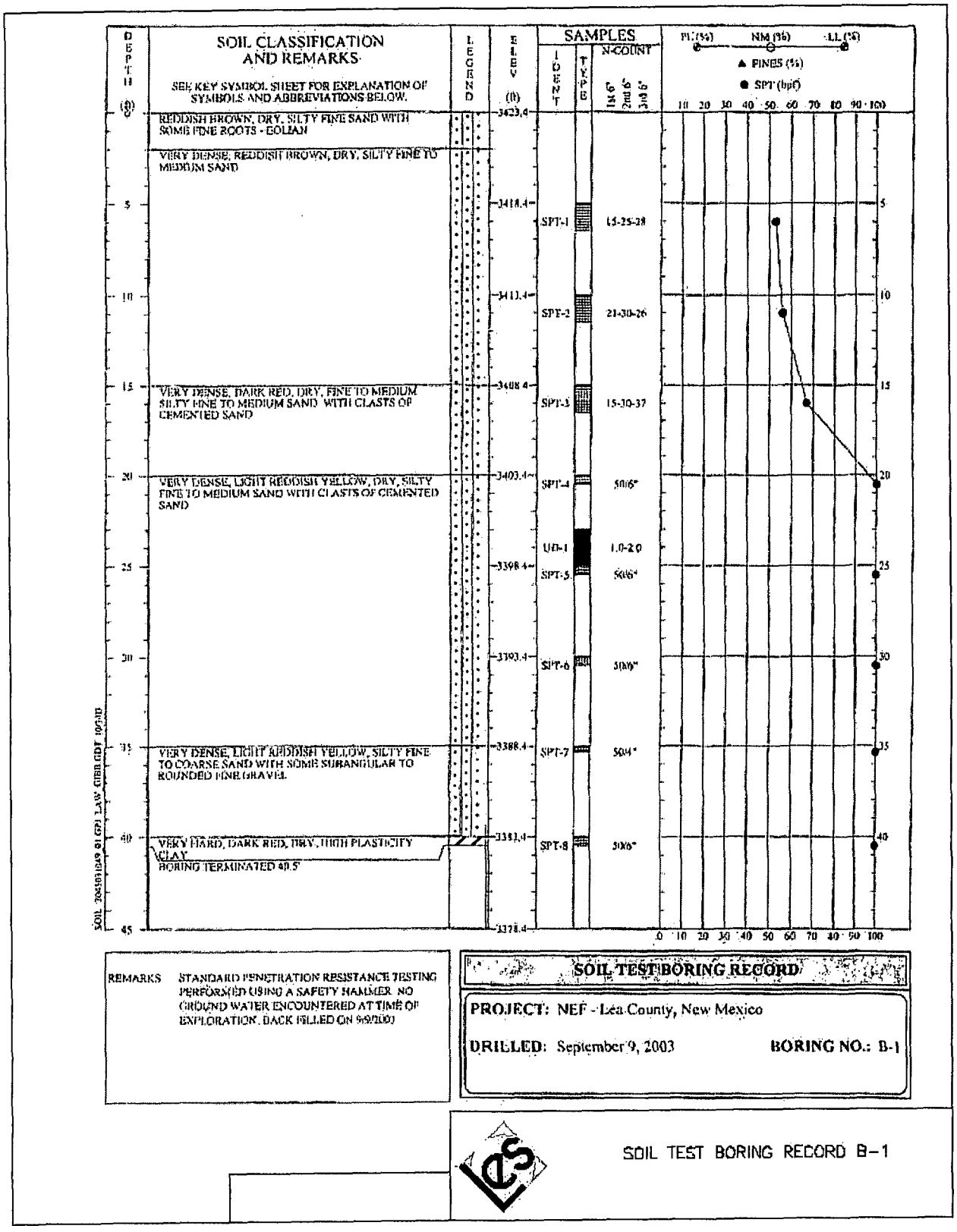


Figure 3.2-10 Soil Test Boring Record B-1

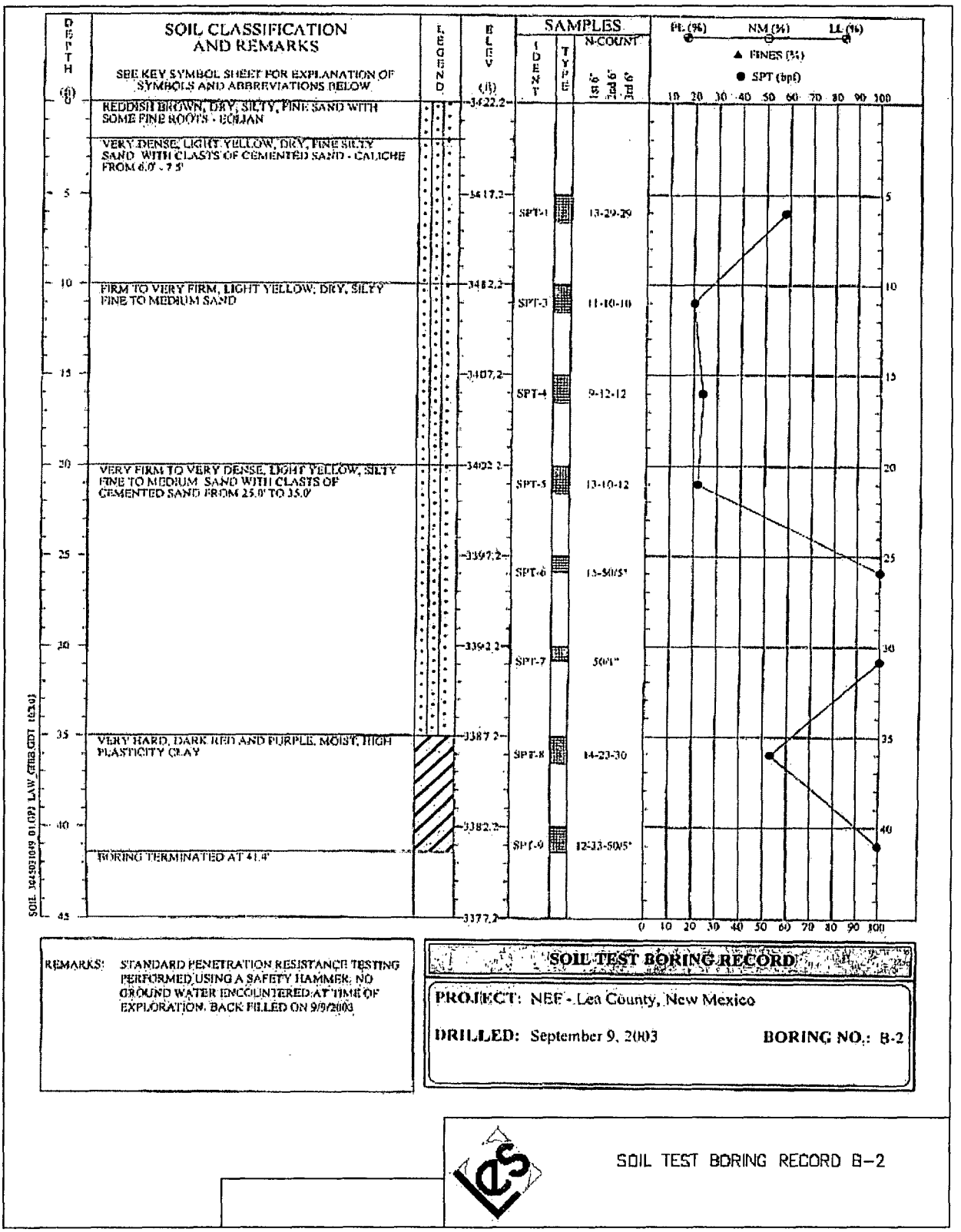


Figure 3.2-11 Soil Test Boring Record B-2

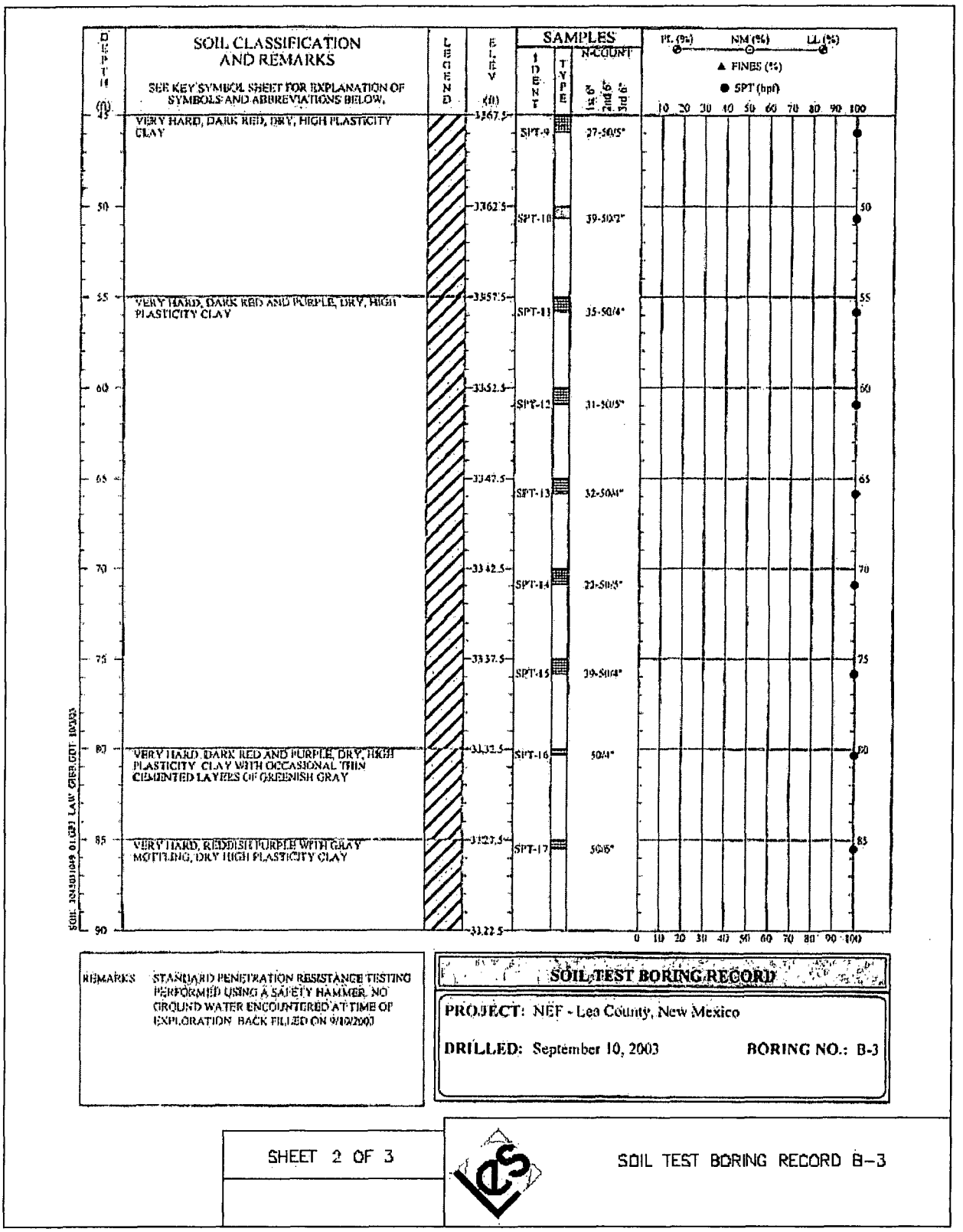


Figure 3.2-12a Soil Test Boring Record B-3, Sheet 1

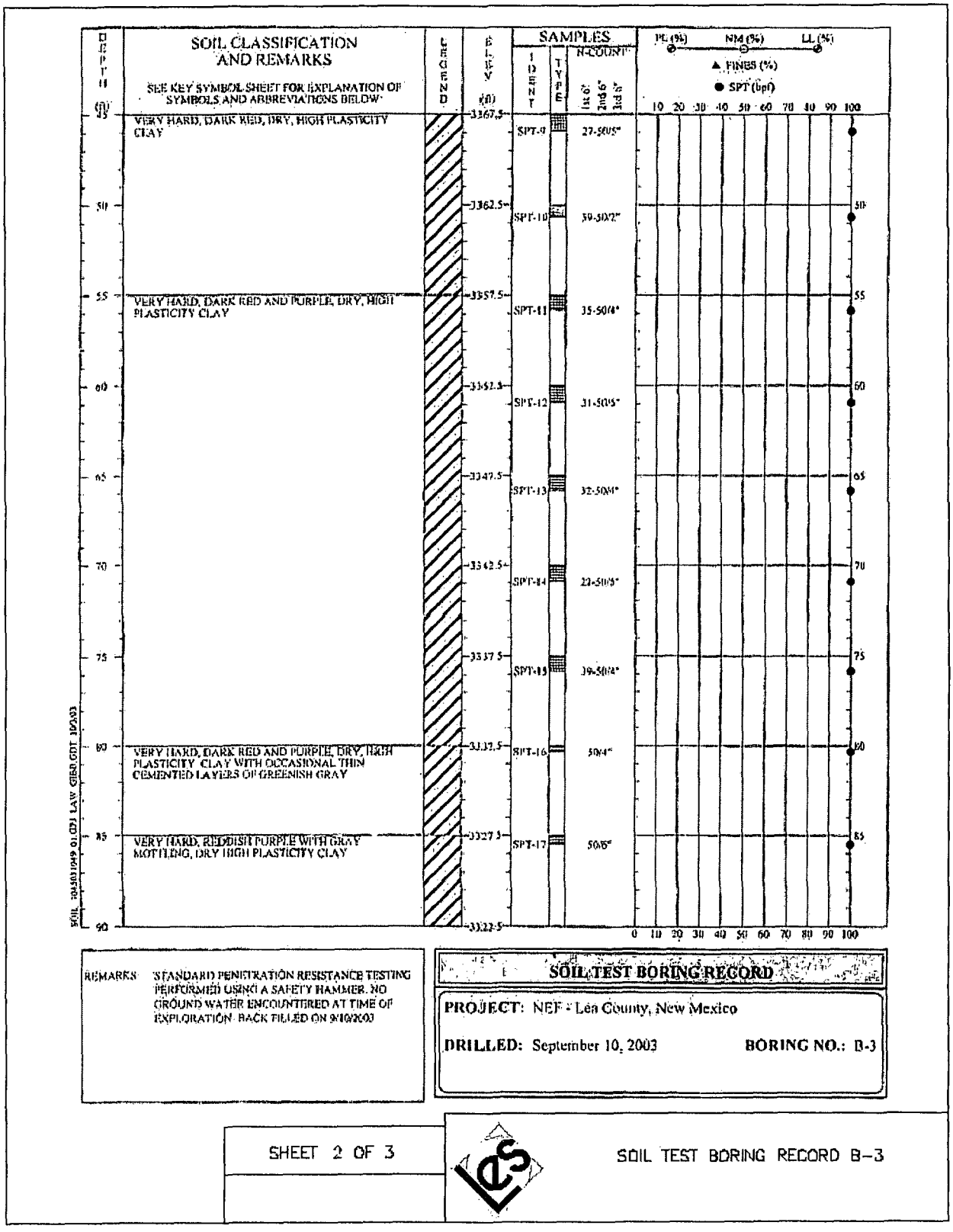


Figure 3.2-12b Soil Test Boring Record B-3, Sheet 2

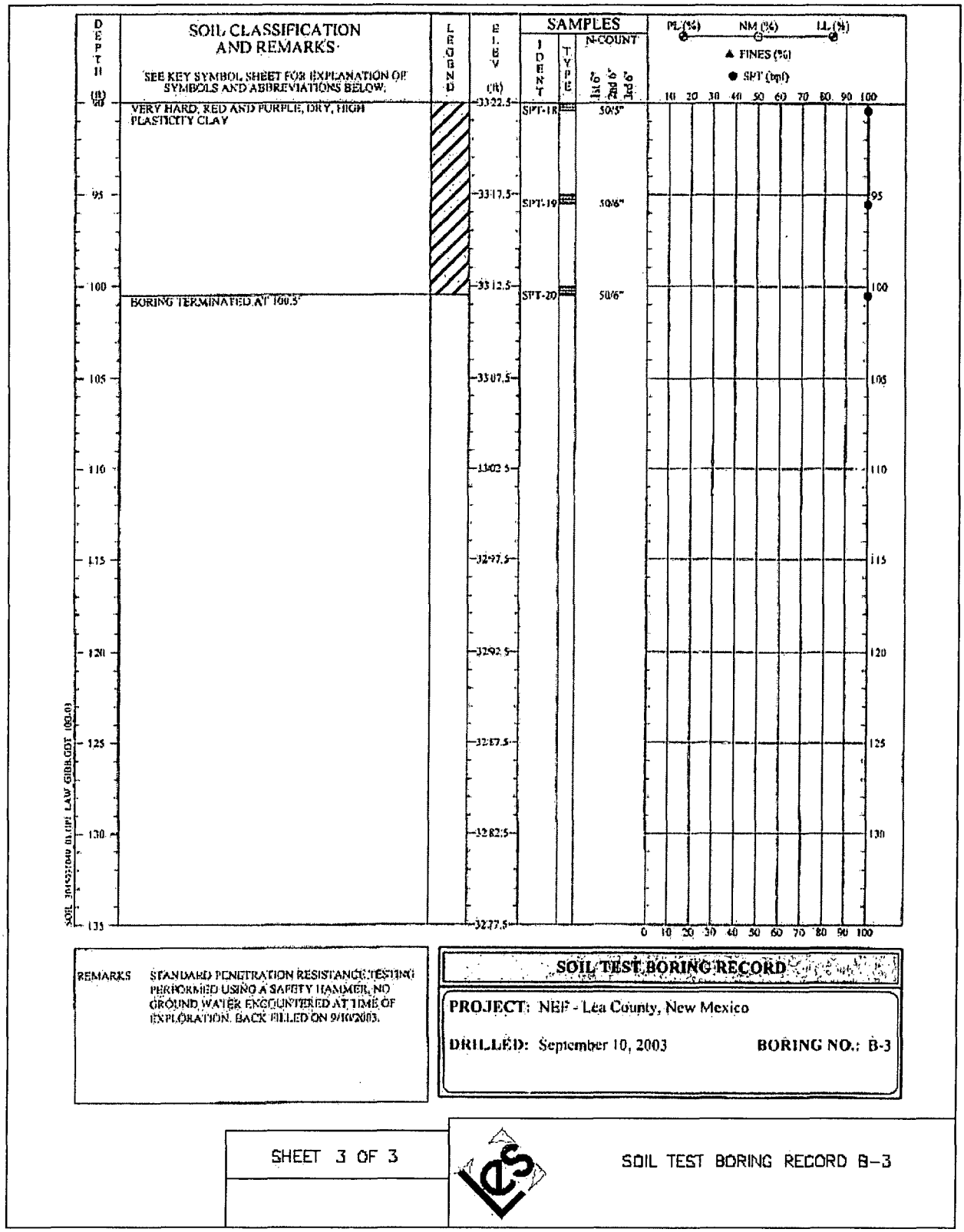


Figure 3.2-12c Soil Test Boring Record B-3, Sheet 3

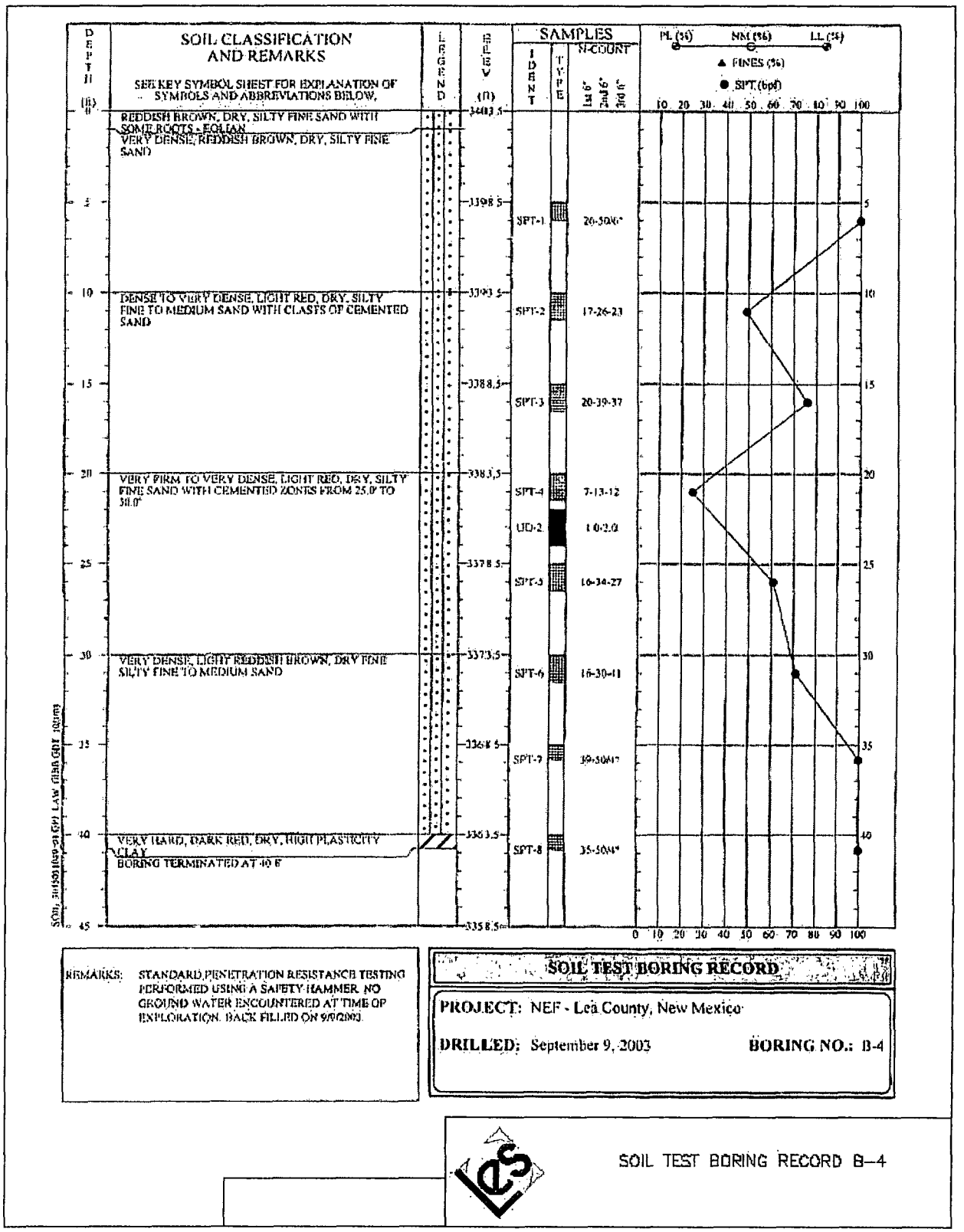


Figure 3.2-13 Soil Test Boring Record B-4

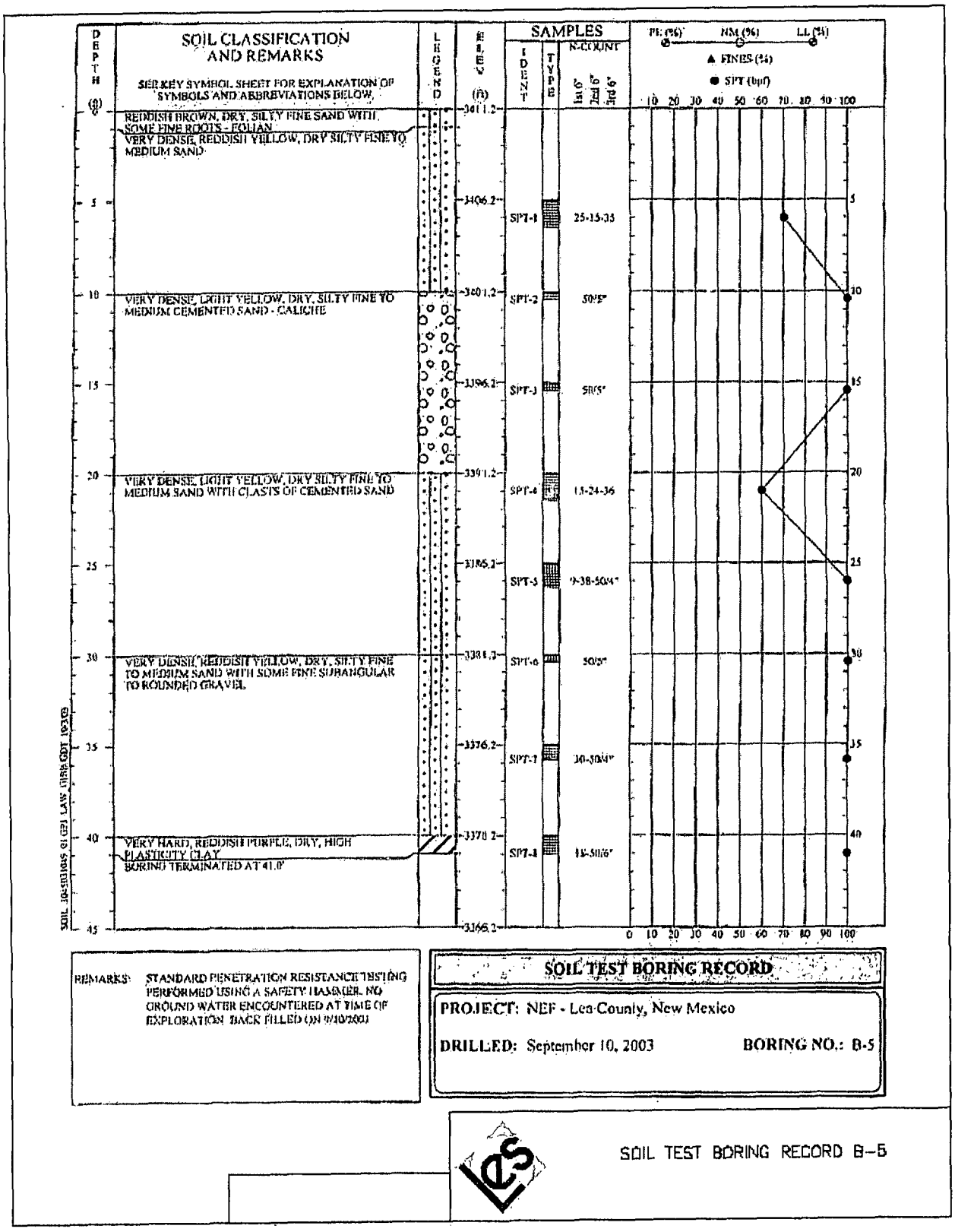


Figure 3.2-14 Soil Test Boring Record B-5

GROUP SYMBOLS	TYPICAL NAMES	GROUP SYMBOLS	TYPICAL NAMES
	TOPSOIL		CONCRETE
	ASPHALT		DOLOMITE
	GRAVEL		LIMESTONE
	FILL		SHALE
	SUBSOIL		LIMESTONE/SHALE - Limestone with shale laminate
	ALLUVIUM		SANDSTONE
	COLLUVIUM		SILTSTONE
	RESIDUUM - Soft to firm		AUGER BORING
	RESIDUUM - Stiff to very hard		UNDISTURBED SAMPLE AT DEPTH

	Undisturbed Sample 1.5-2.0 = Recovered (ft) / Pushed (ft)
	Split Spoon Sample
	Auger Cuttings
	Rock Core 60-100 = RQD / Recovery
	Dilatometer
	No Sample
	Crandall Sampler
	Rotary Drill
	Pressure Meter
	Water Table at time of drilling
	No Recovery
	Water Table after 24 hours

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols.

SILT OR CLAY	SAND			GRAVEL		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

No.100 No.40 No.10 No.4 3/4" 3" 12"

U.S. STANDARD SIEVE SIZE

Reference: The Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Vol. 1, March, 1953 (Revised April, 1960)

Correlation of Penetration Resistance with Relative Density and Consistency

SAND & GRAVEL		SILT & CLAY	
No. of Blows	Relative Density	No. of Blows	Consistency
0 - 4	Very Loose	0 - 2	Very Soft
5 - 10	Loose	3 - 4	Soft
11 - 20	Firm	5 - 8	Firm
21 - 30	Very Firm	9 - 15	Stiff
31 - 50	Dense	16 - 30	Very Stiff
Over 50	Very Dense	31 - 50	Hard
		Over 50	Very Hard

SOIL TEST BORING KEY TO SYMBOLS AND DESCRIPTIONS

Figure 3.2-15 Soil Test Boring Key to Symbols and Descriptions

Figure 3.2-16 Deleted

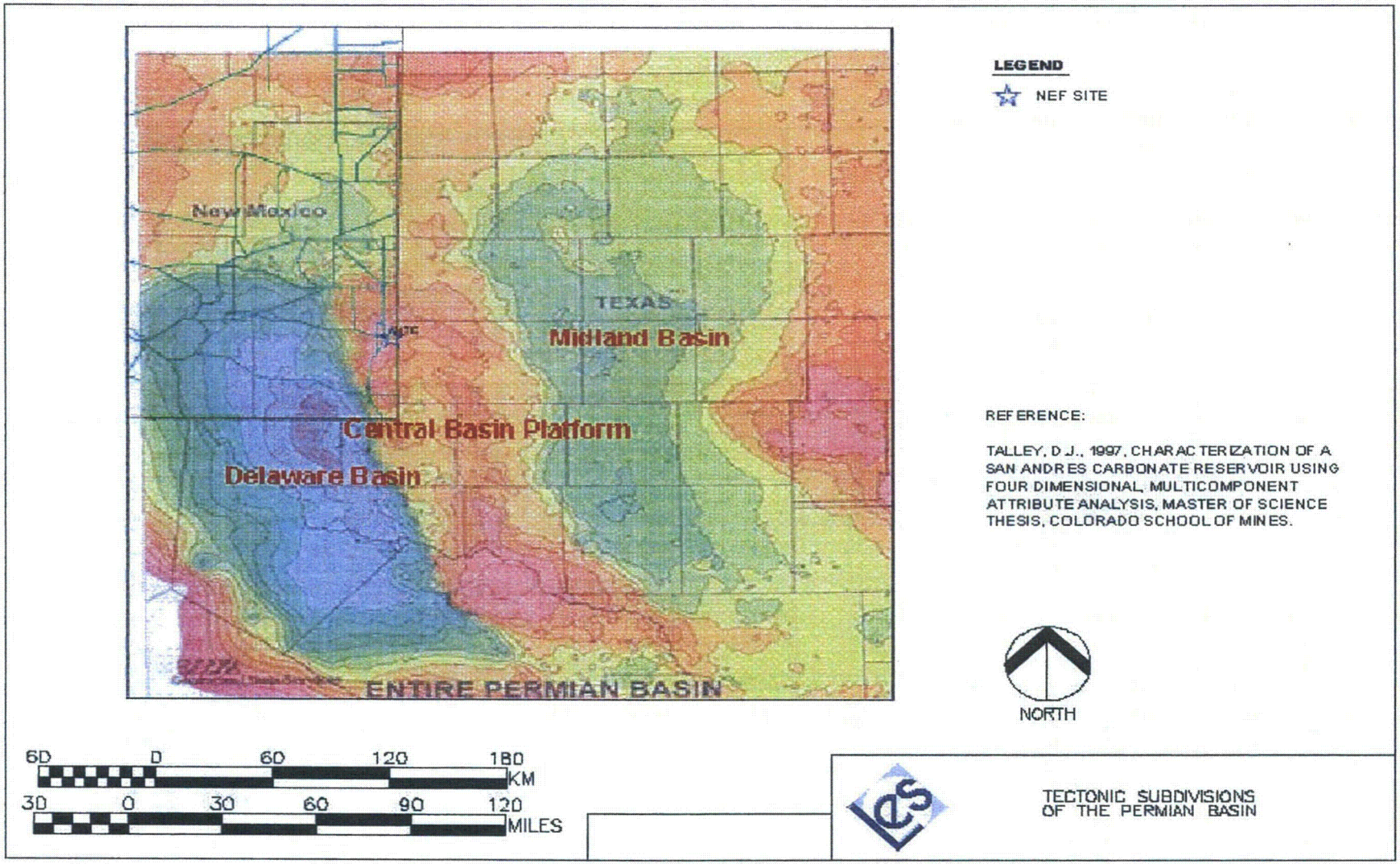


Figure 3.2-17 Tectonic Subdivisions of the Permian Basin

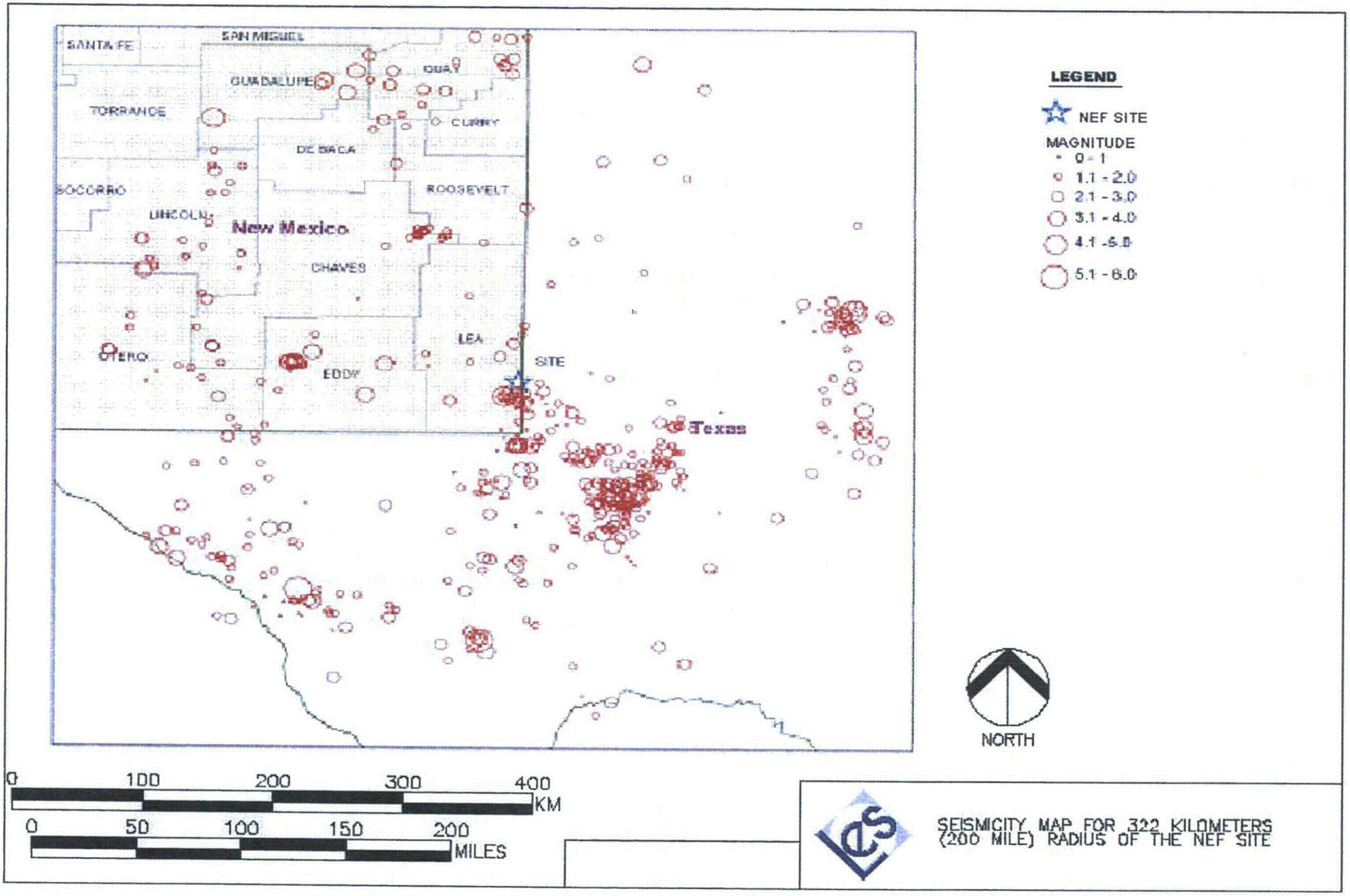


Figure 3.2-18 Seismicity Map for 322 Kilometers (200Mile) Radius of the NEF Site

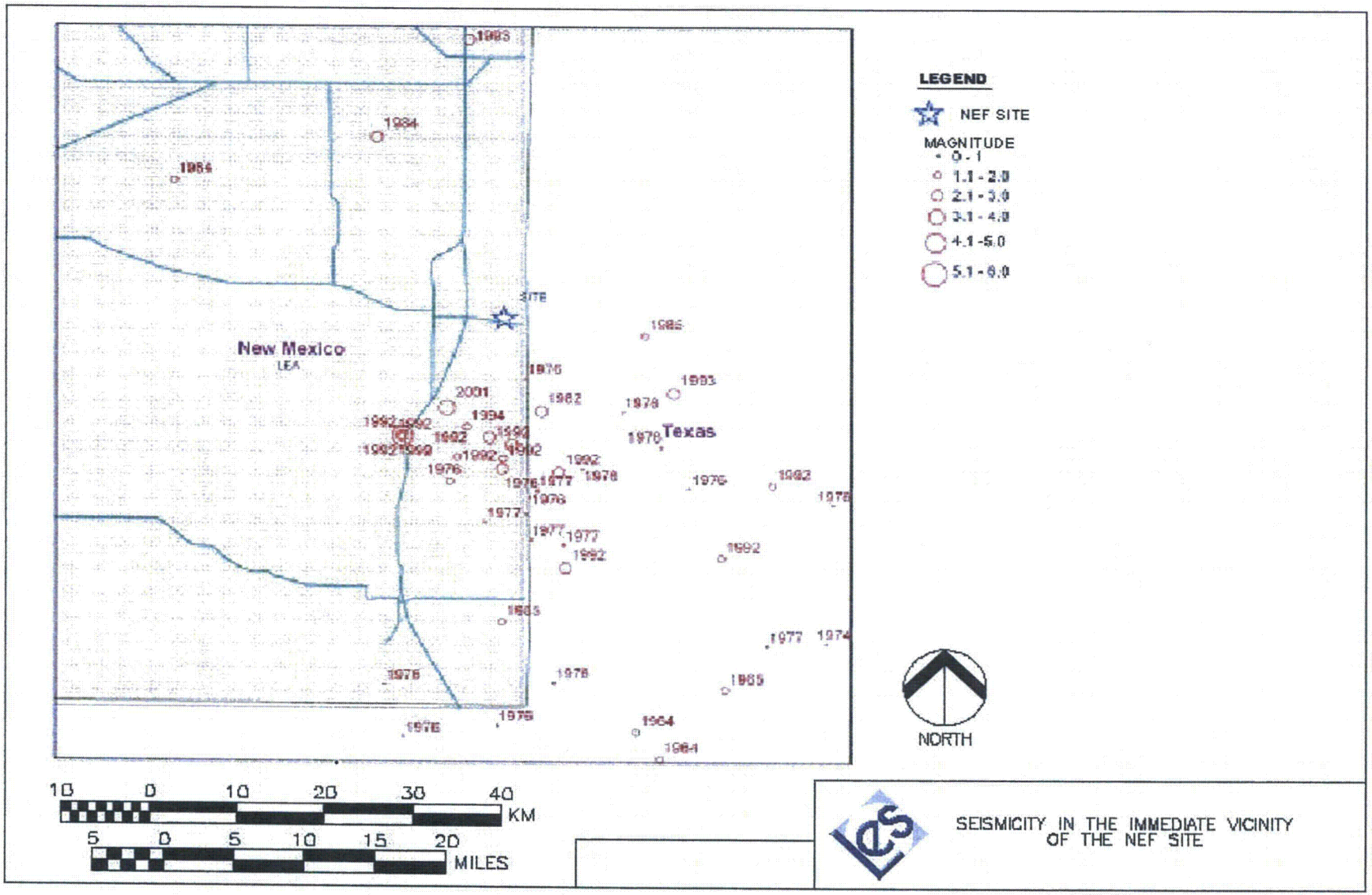


Figure 3.2-19 Seismicity in the Immediate Vicinity of the NEF Site

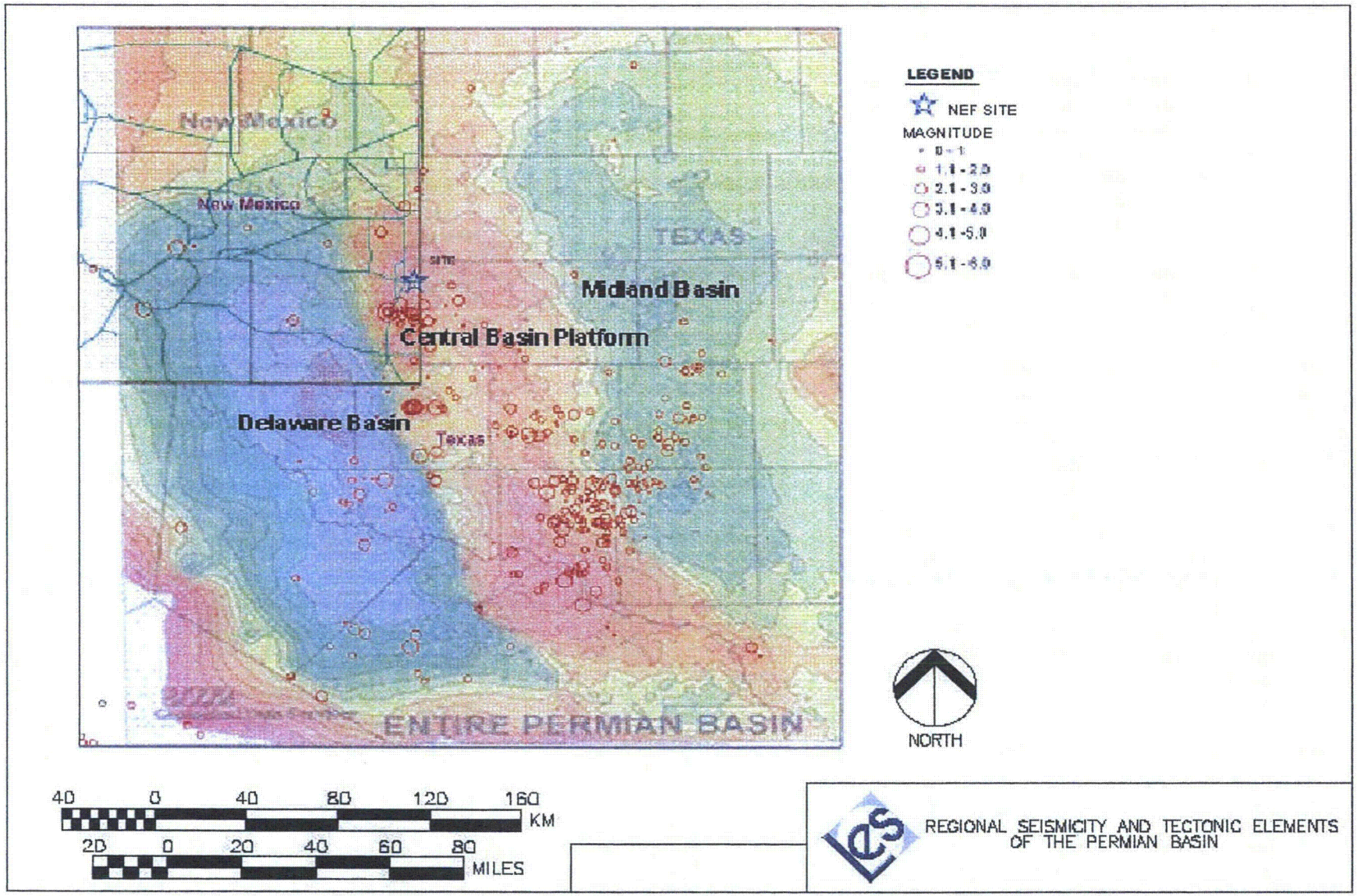


Figure 3.2-20 Regional Seismicity and Tectonic Elements of the Permian Basin

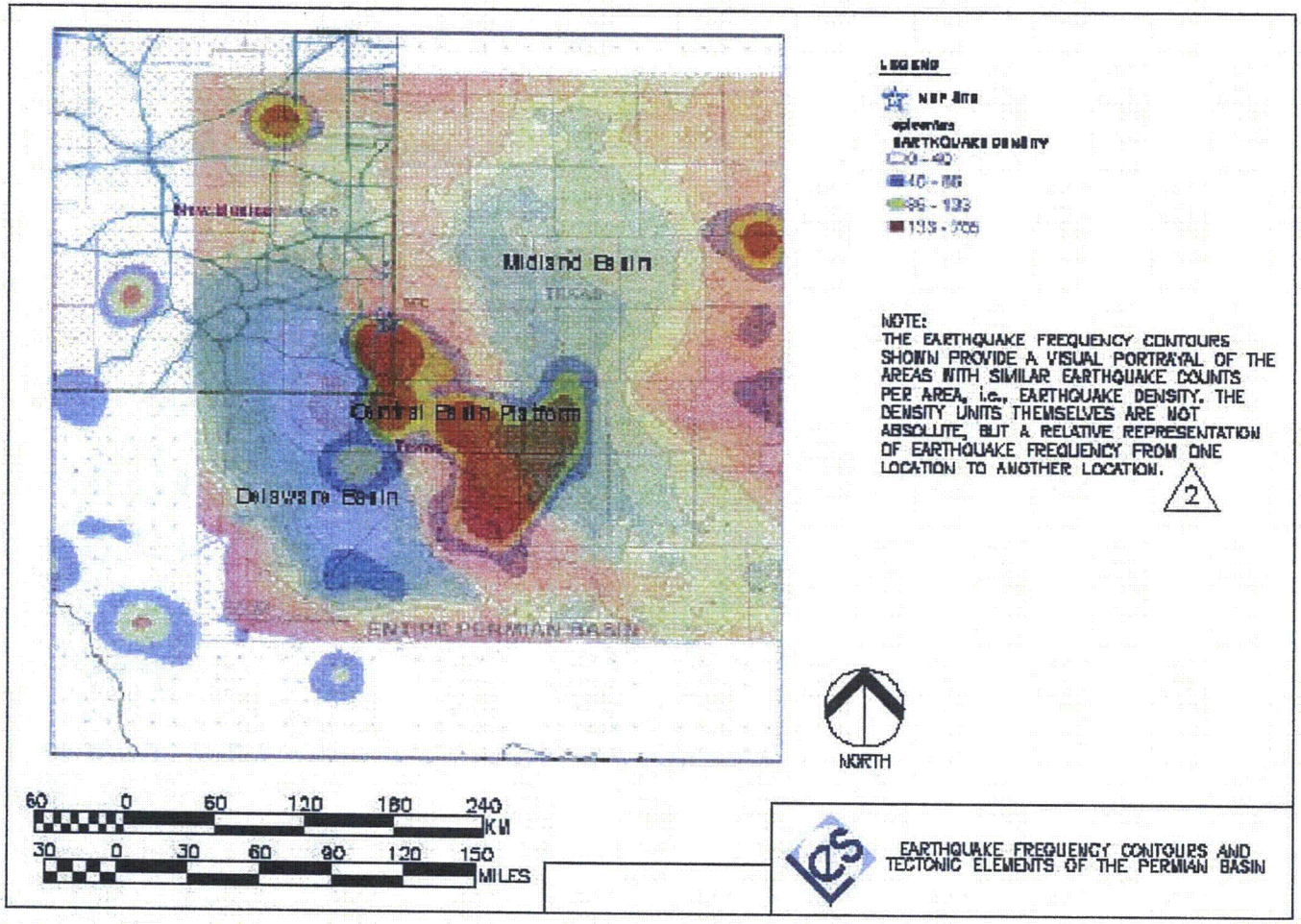


Figure 3.2-21 Earthquake Frequency Contours and Tectonic Elements of the Permian Basin

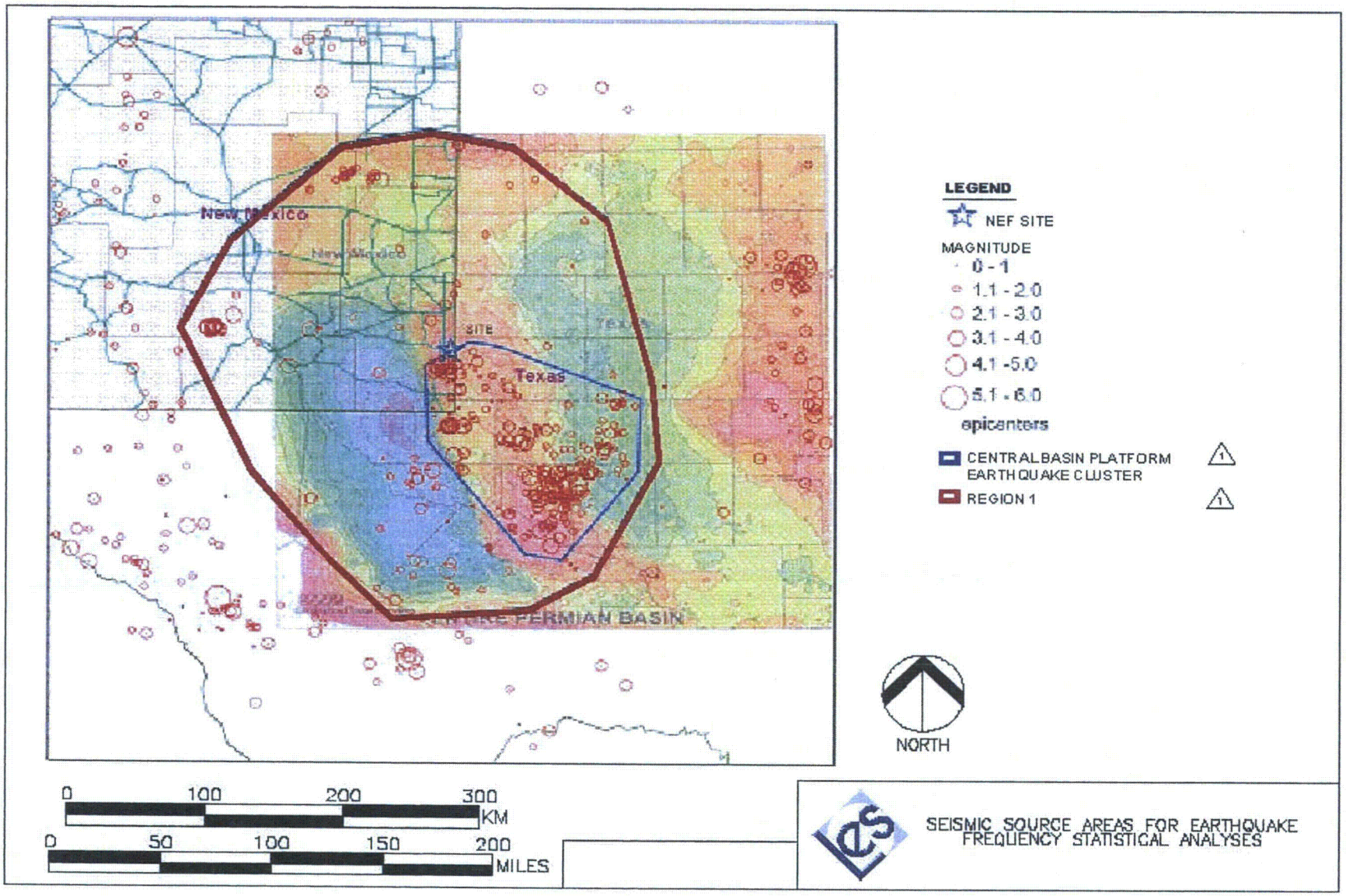
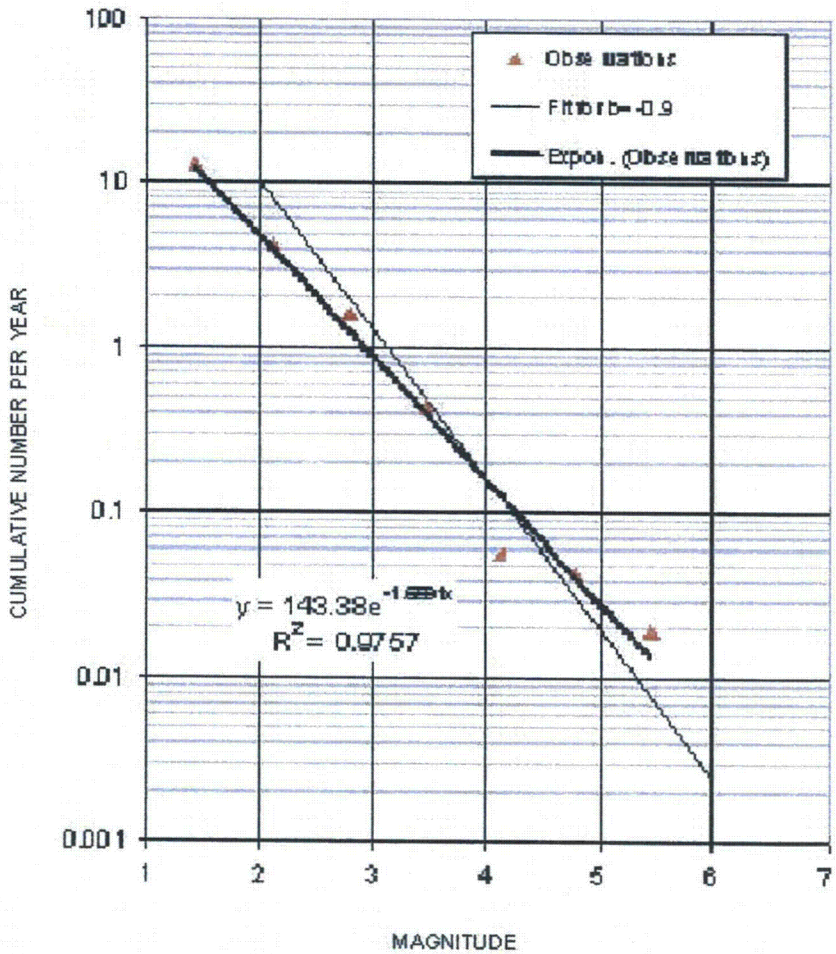


Figure 3.2-22 Seismic Source Areas for Earthquake Frequency Statistical Analyses



Exponential Best Fit

Log(Nc) = 2.15 – 0.74(M)

Fit assuming b = -0.90

Log(Nc) = 2.80 – 0.90(M)

M IS MAGNITUDE SCALED TO DURATION MAGNITUDE AS DESCRIBED IN NEW MEXICO TECH CATALOGS CIRULAR 210, 2002

EARTHQUAKE RECURRENCE MODELS FOR THE 322 KM (200 MILE) RADIUS COMPOSITE CATALOG

Figure 3.2-23 Earthquake Recurrence Models for the 322 km (200-mile) Radius Composite Catalog

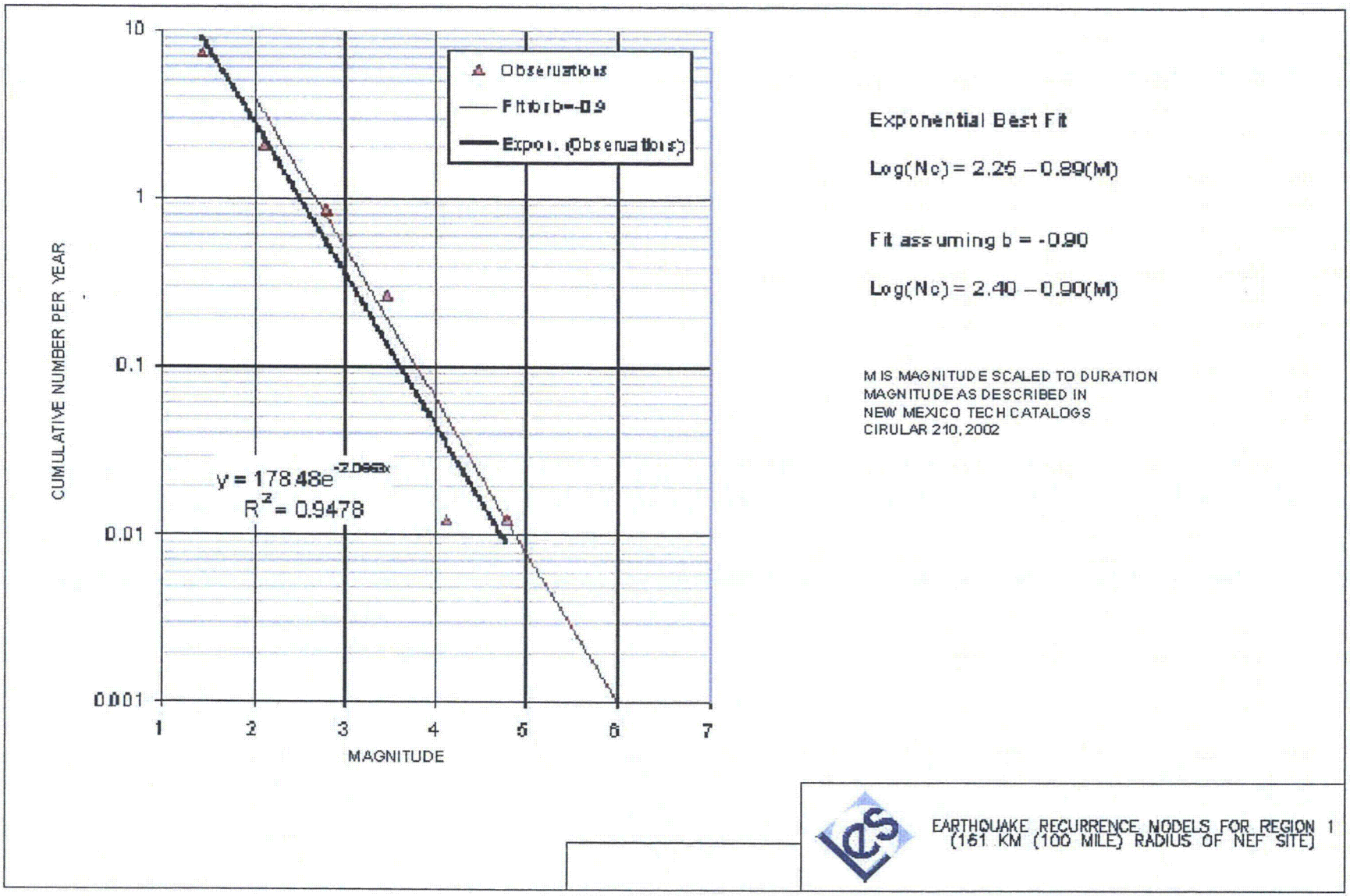


Figure 3.2-24 Earthquake Recurrence Models for Region 1 –(161 km (100mile) Radius of the NEF Site)

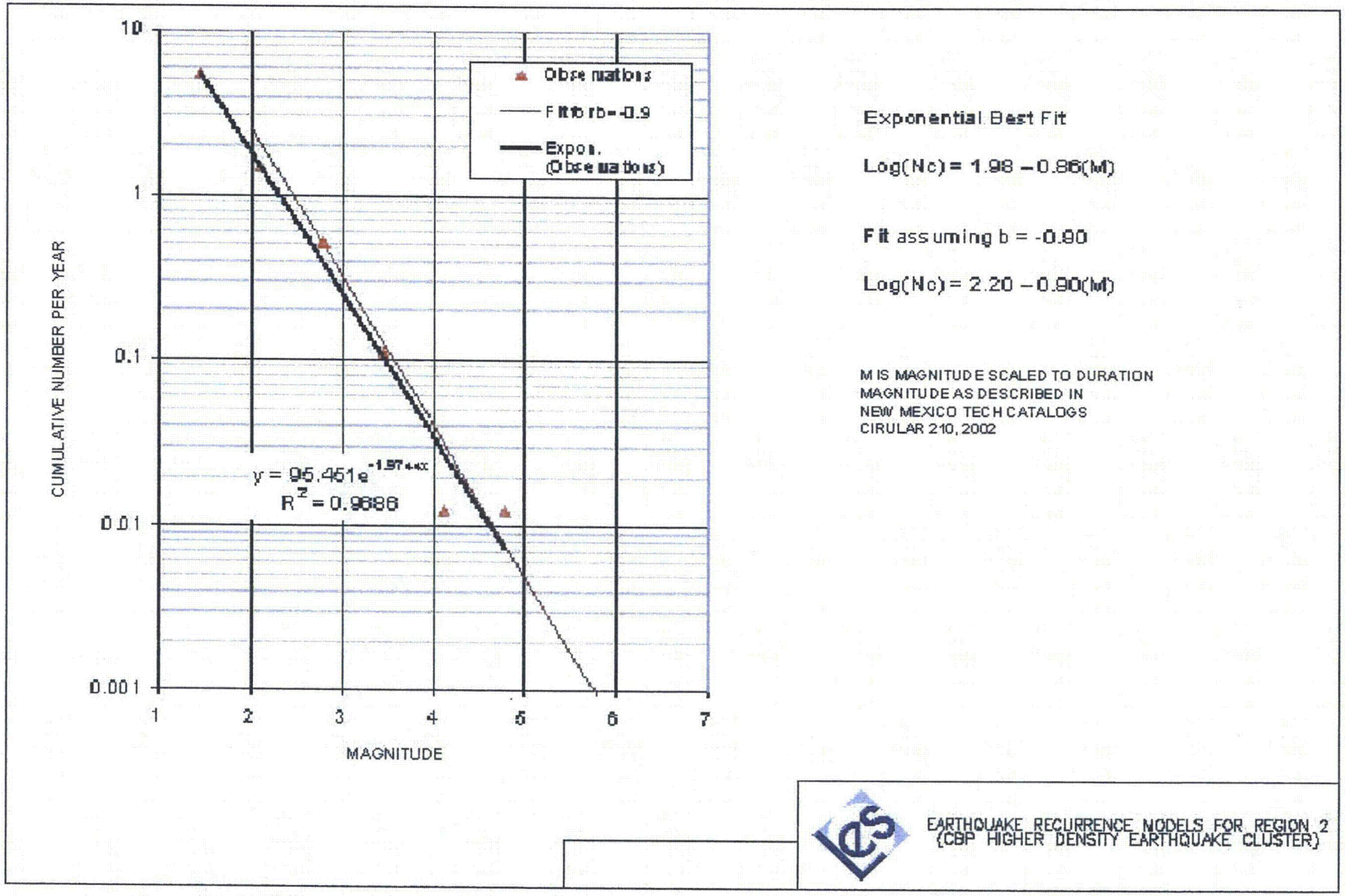


Figure 3.2-25 Earthquake Recurrence Models for Region 2 (CBP Higher Density Earthquake Cluster)

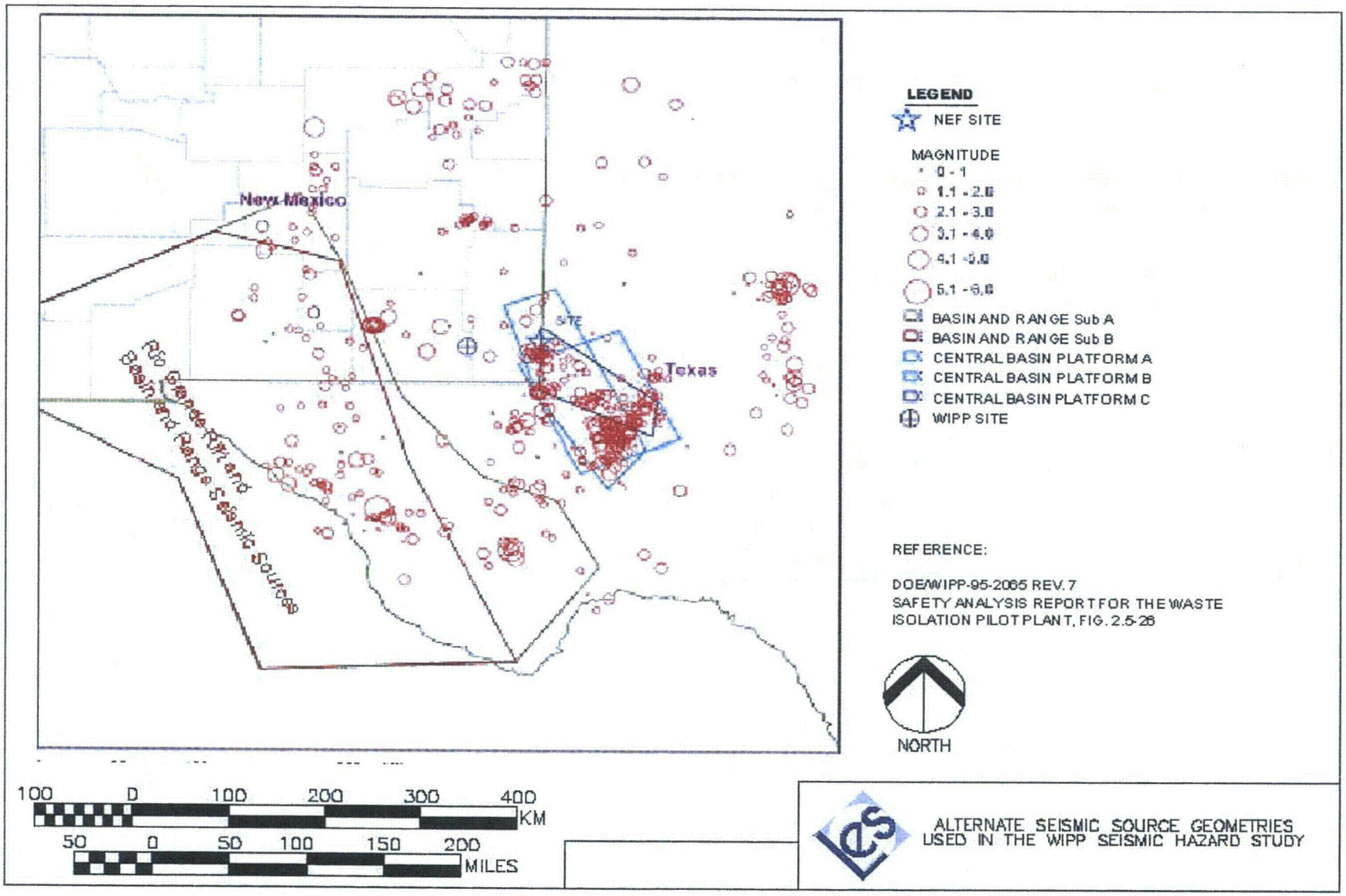


Figure 3.2-26 Alternate Seismic Source Geometries Used in the WIPP Seismic Hazard Study

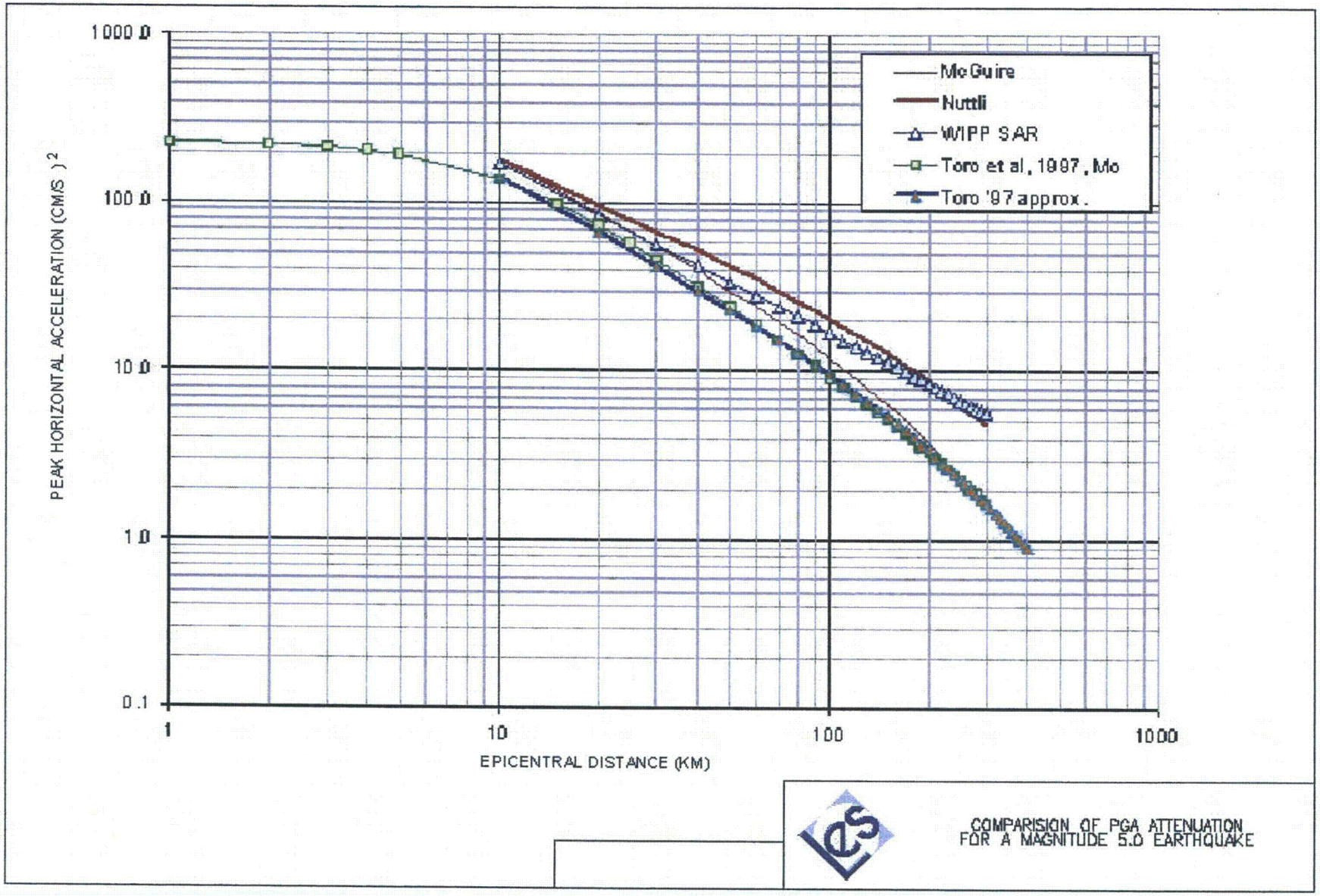


Figure 3.2-27 Comparison of PGA Attenuation for a Magnitude 5.0 Earthquake

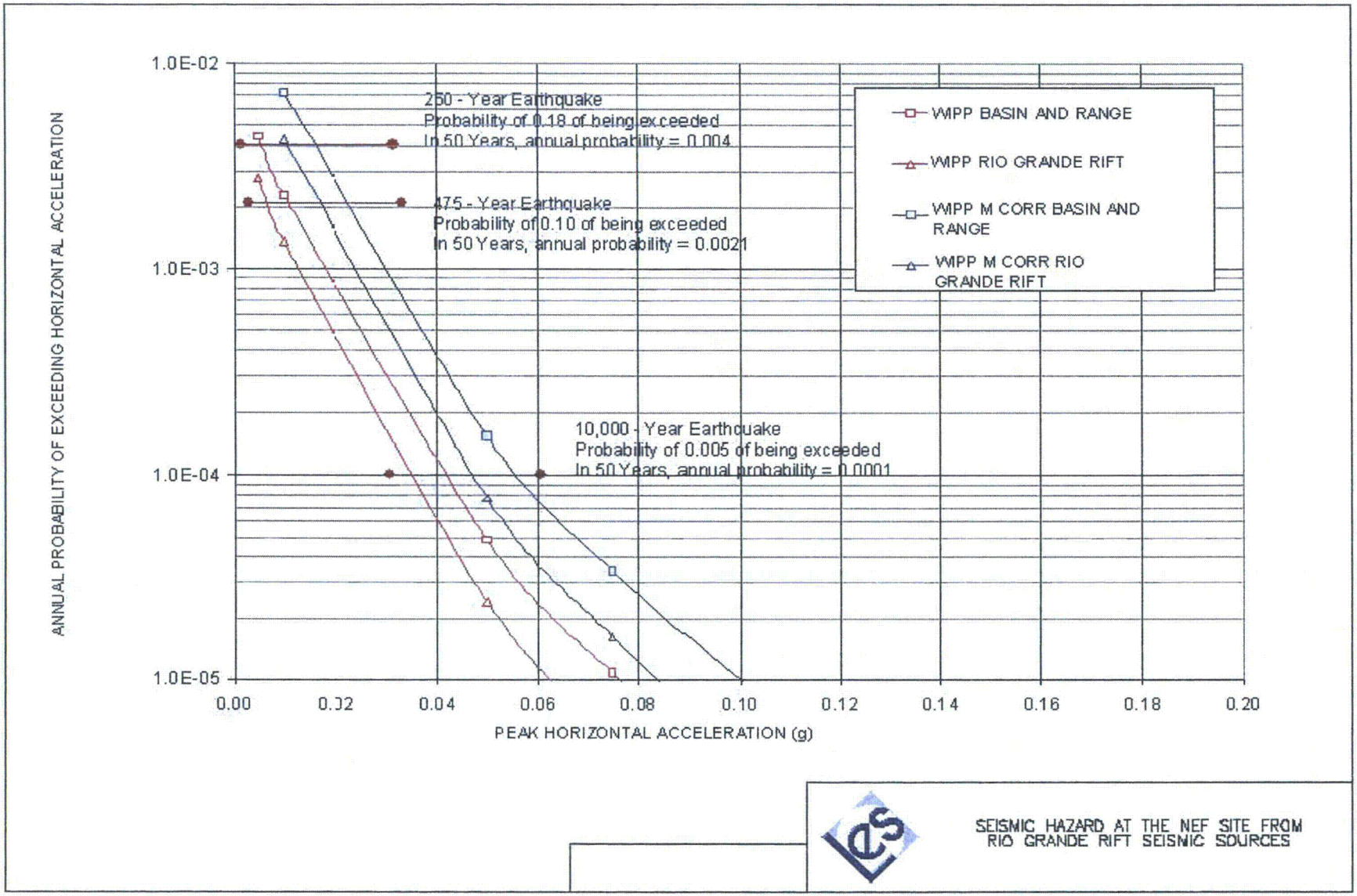


Figure 3.2-28 Seismic Hazard at the NEF Site From Rio Grande Rift Seismic Sources

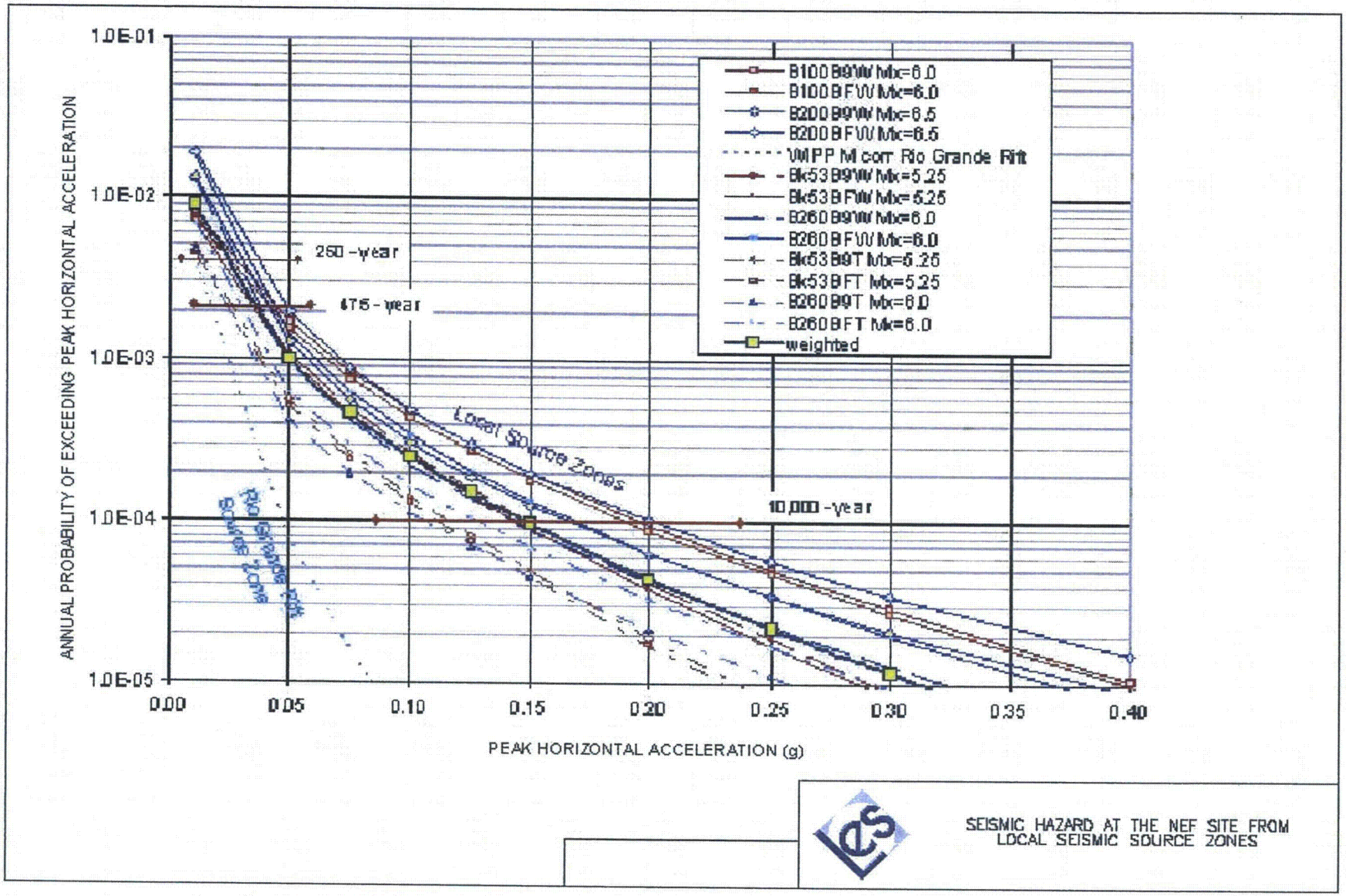


Figure 3.2-29 Seismic Hazard at the NEF Site From Local Seismic Source Zones

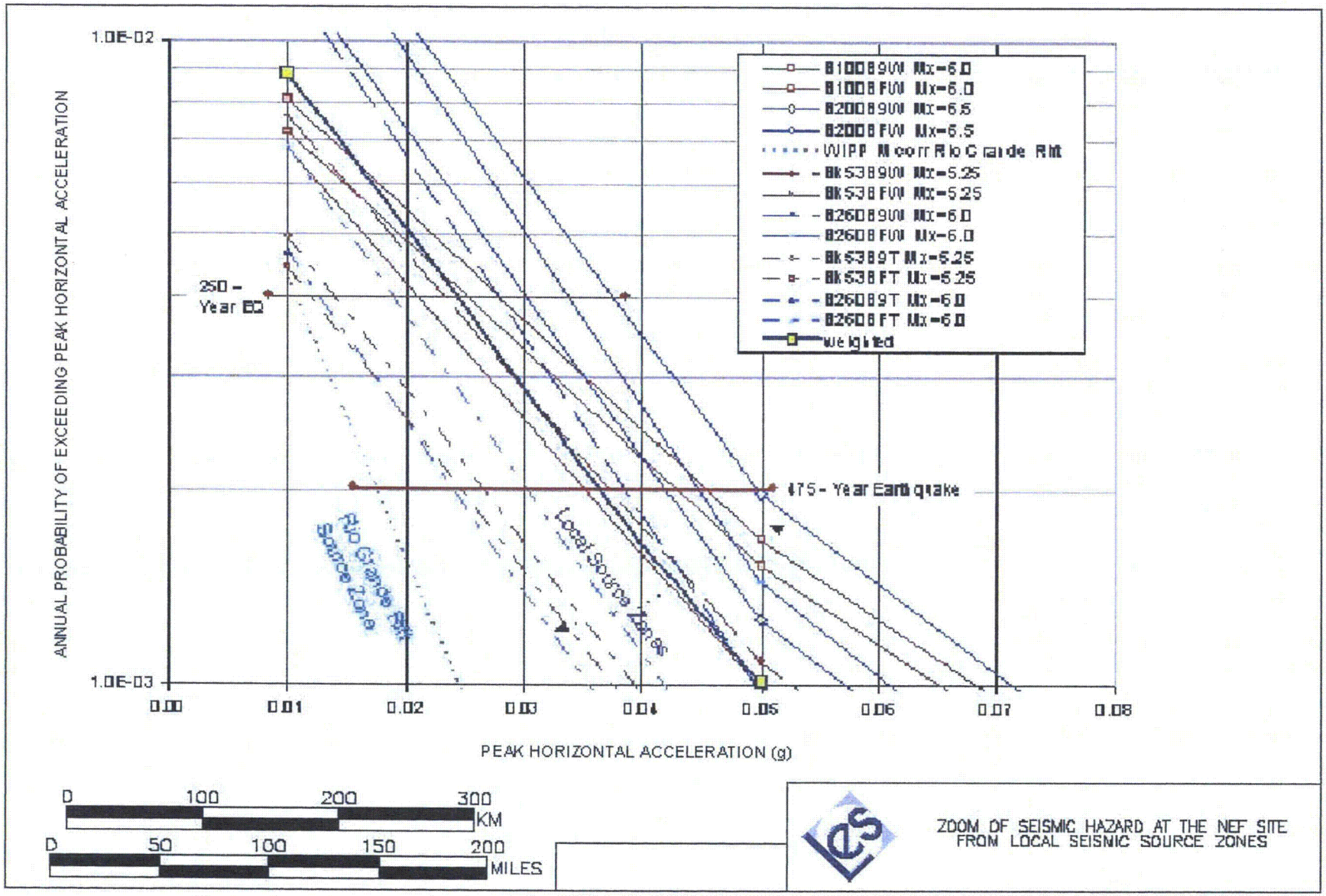
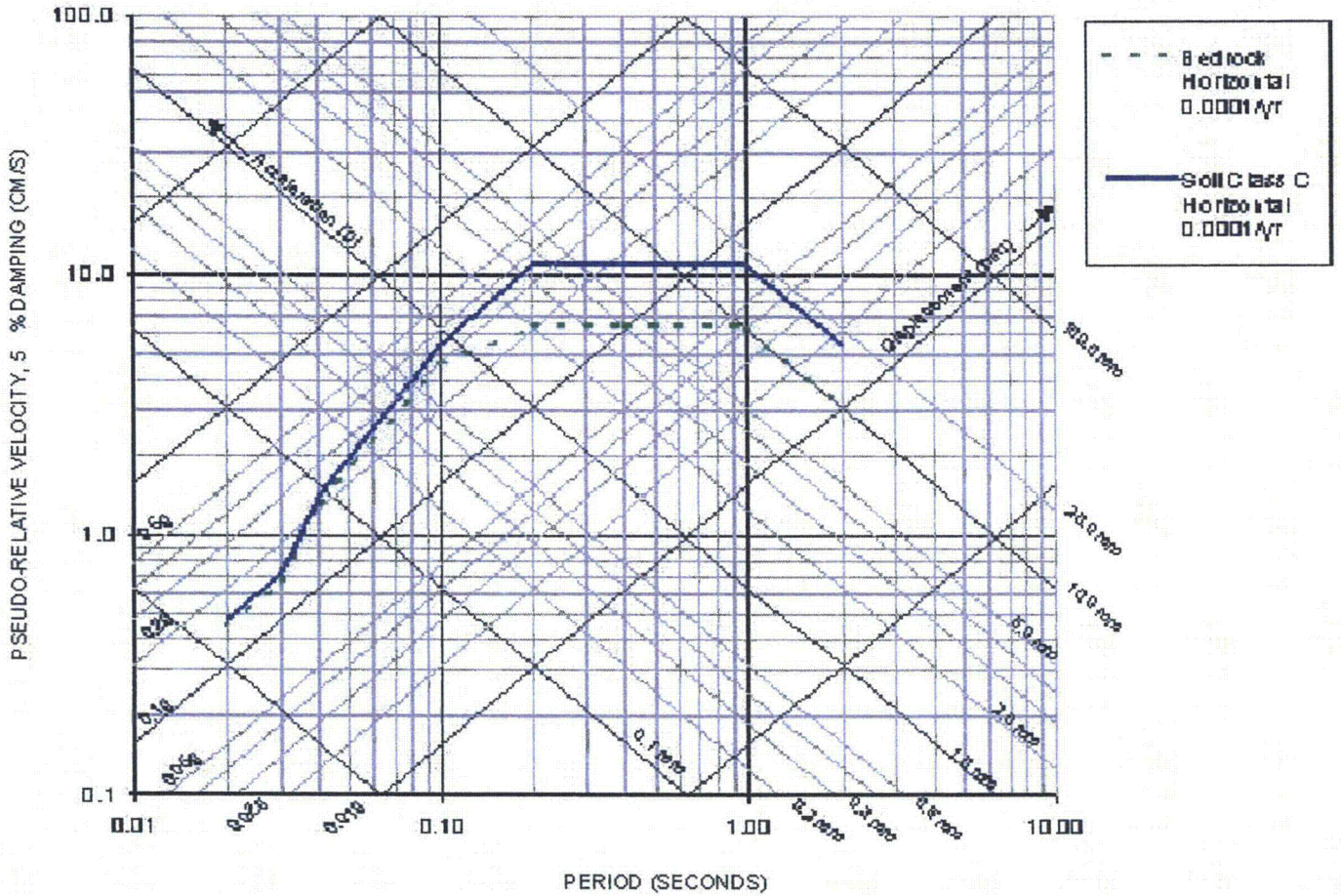


Figure 3.2-30 Zoom of Seismic Hazard at the NEF Site From Local Seismic Source Zones



HORIZONTAL RESPONSE SPECTRA FOR THE 10,000-YEAR EARTHQUAKE – BEDROCK AND SOIL CLASS C FOR THE NEF SITE

Figure 3.2-31 Horizontal Response Spectra for the 10,000-Year Earthquake Bedrock and Soil Class C for the NEF Site

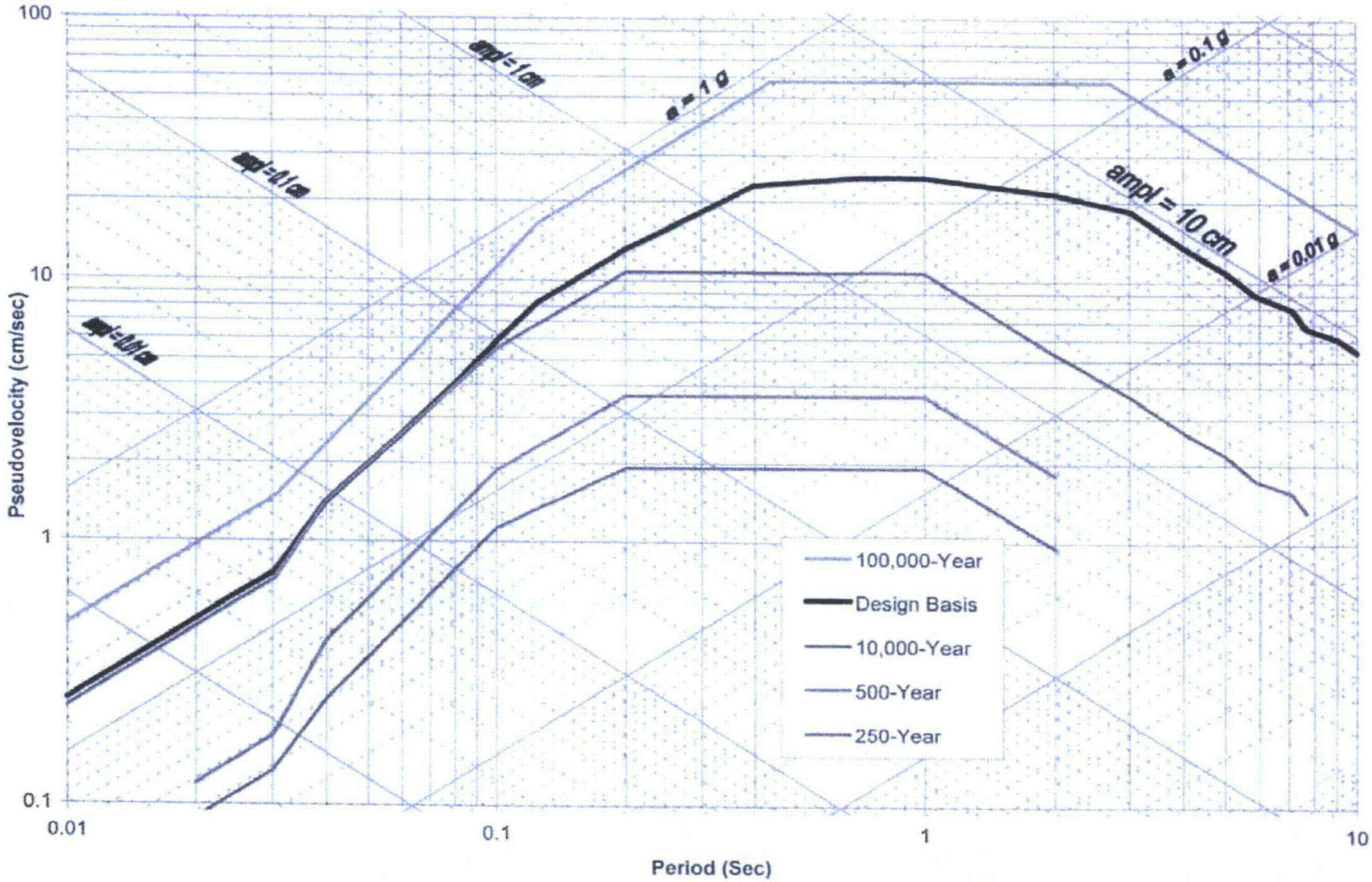


Figure 3.2-32 Horizontal Response Spectra Variable Earthquake Periodicity Soil Class C, 5% Damping

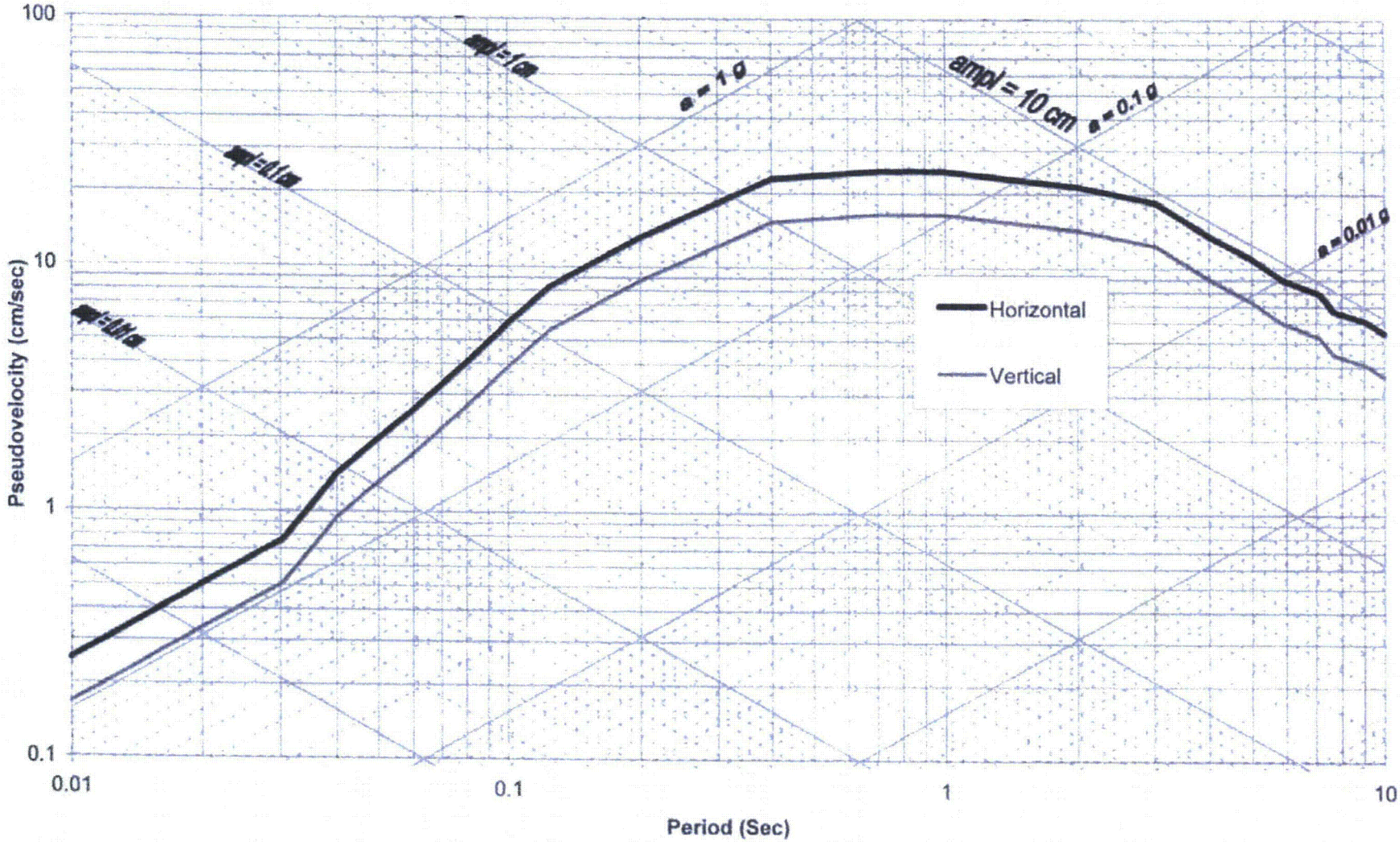


Figure 3.2-32a **Horizontal and Vertical Response Spectra for Design Basis Earthquake, Soil Class C, 5% Damping**

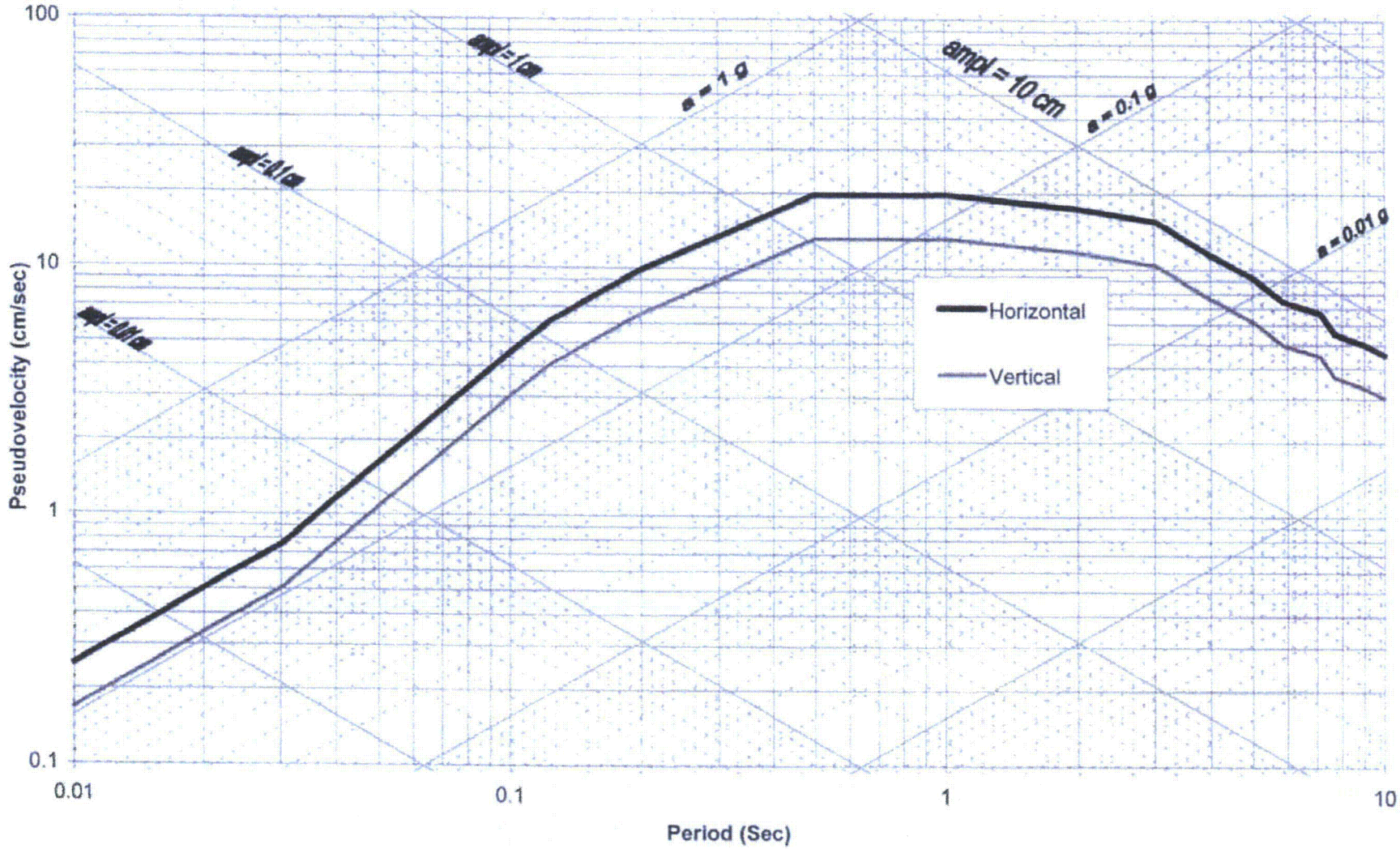
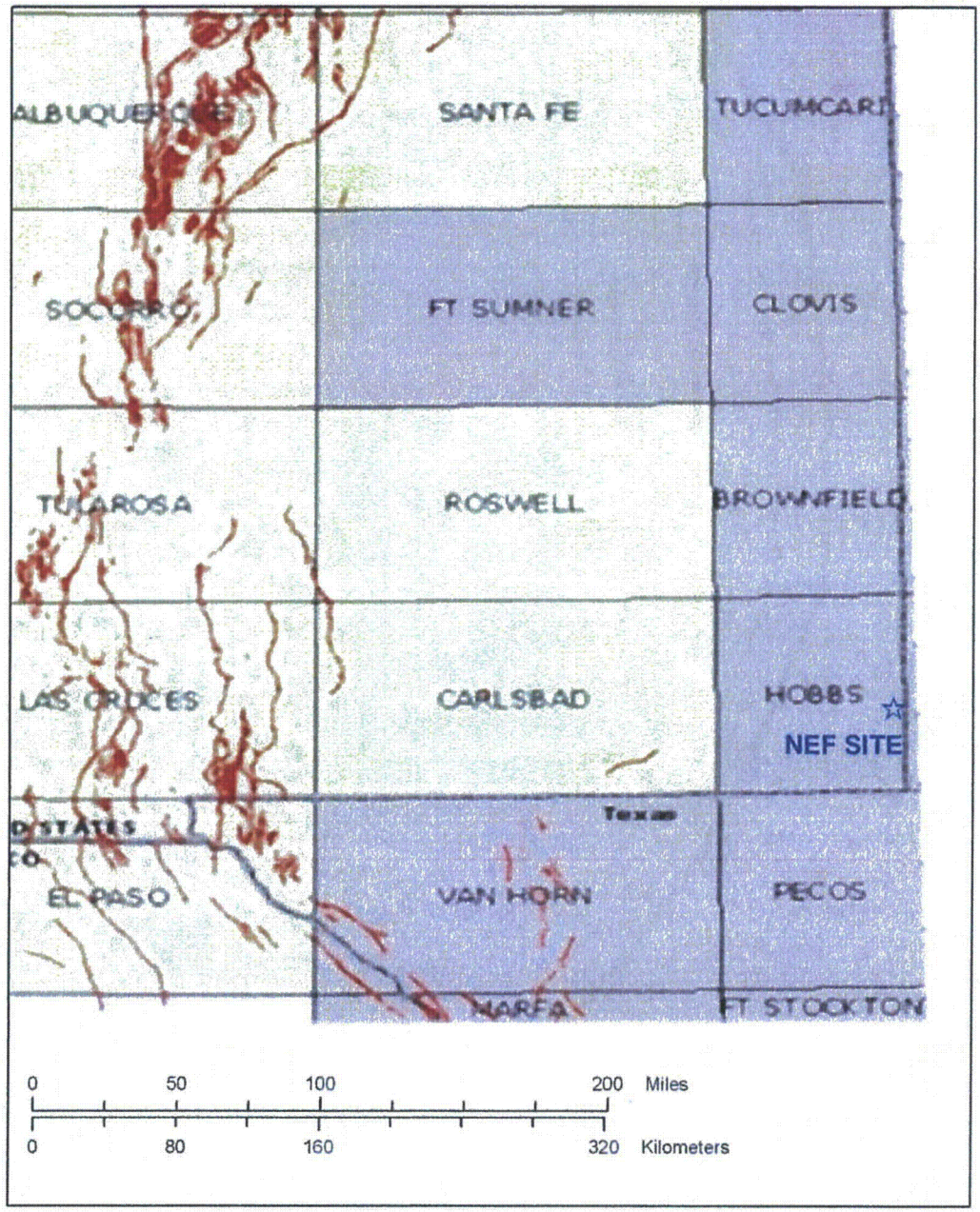


Figure 3.2-32b **Horizontal and Vertical Response Spectra for Design Basis Earthquake, Soil Class C, 10% Damping**

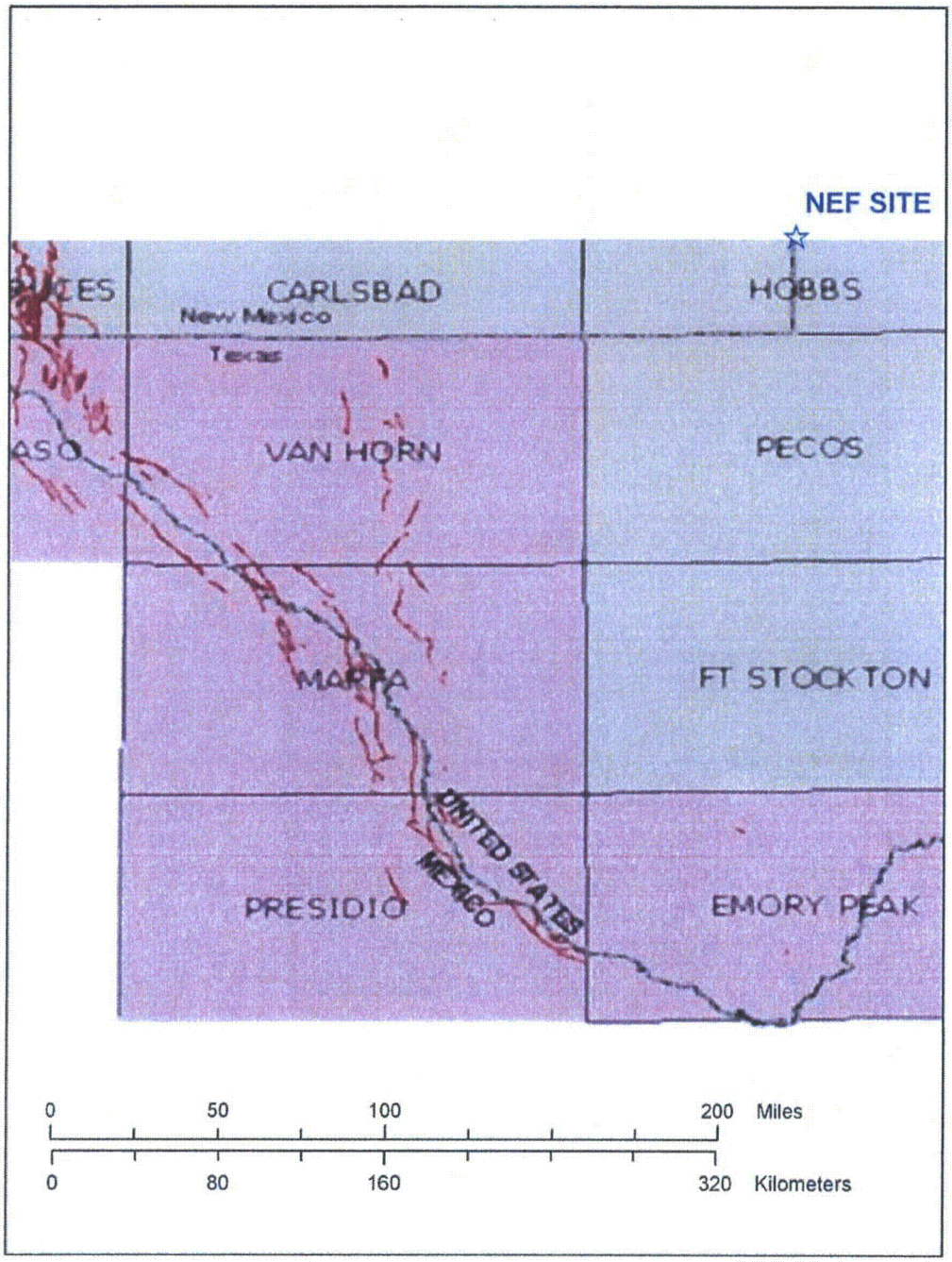


2

SOURCE: Earthquake Hazards Program
Quaternary Fault and Fold Database
(USGS, 2004)

QUATERNARY FAULTS
IN NEW MEXICO

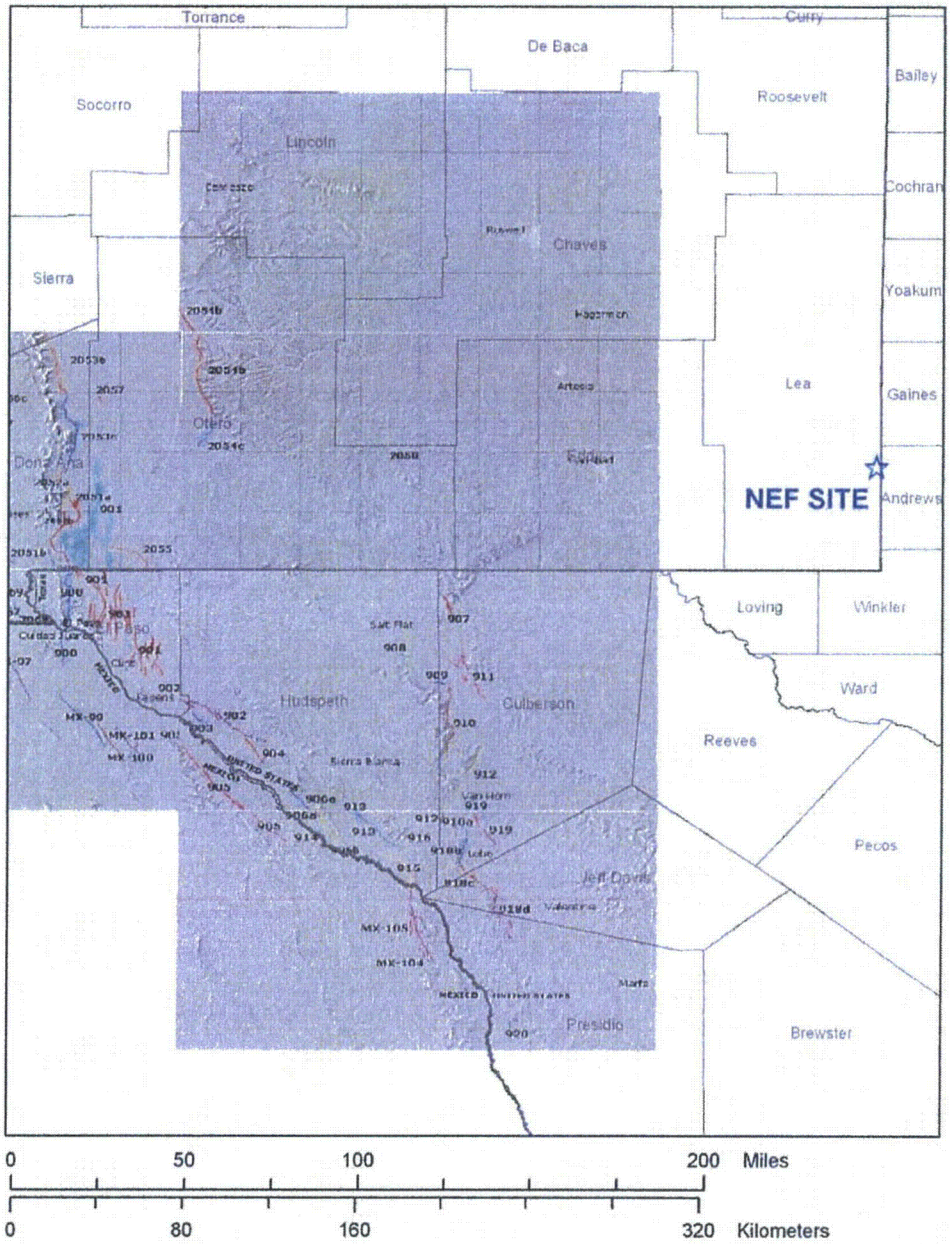
Figure 3.2-33 Quaternary Faults in New Mexico



SOURCE: Earthquake Hazards Program Quaternary Fault and Fold Database (USGS, 2004)

QUATERNARY FAULTS IN TEXAS

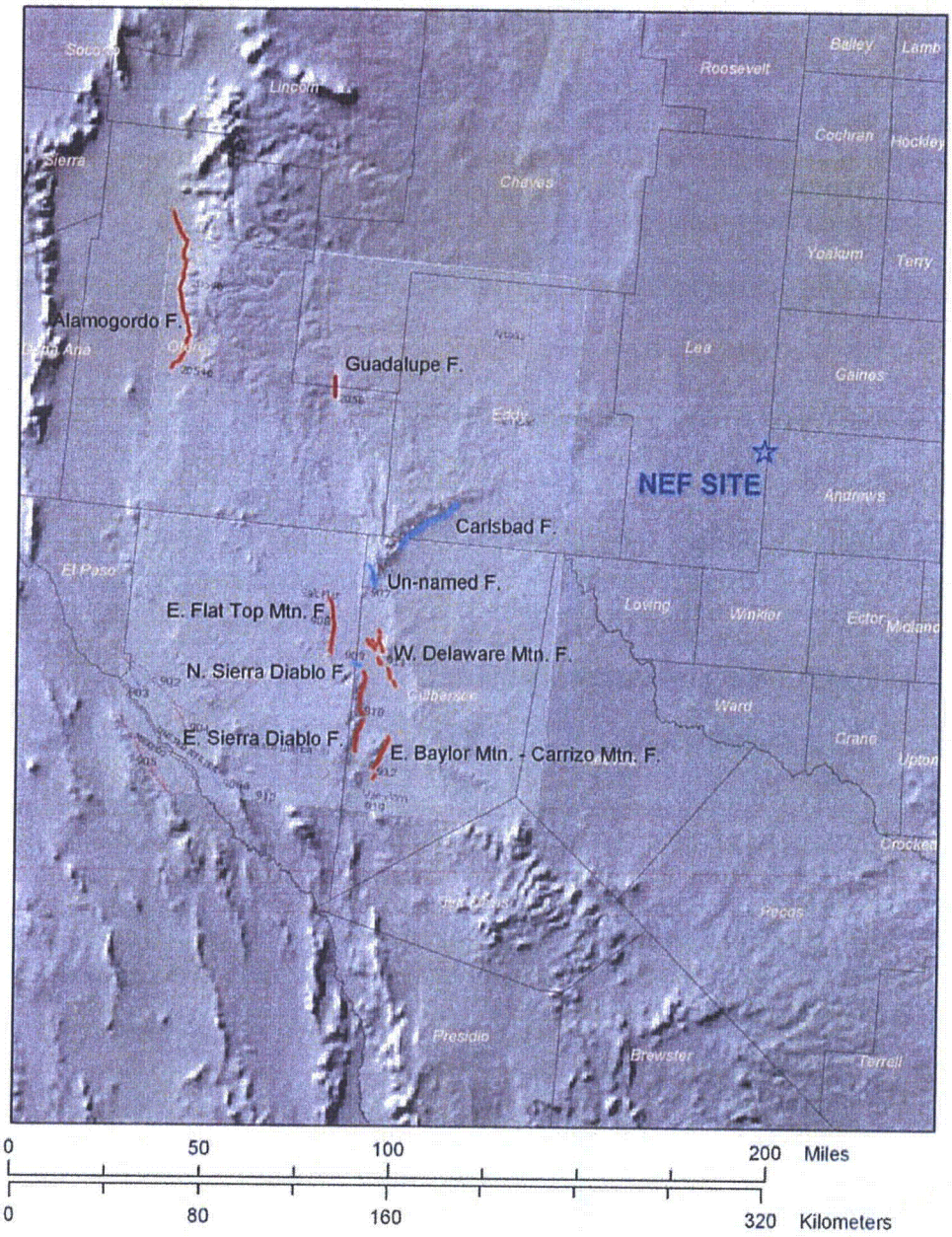
Figure 3.2-34 Quaternary Faults in Texas



SOURCE: USGS, 2004; Machette, 2000

QUATERNARY FAULTS
WITHIN 322 km (200 mi) OF NEF SITE

Figure 3.2-35 Quaternary Faults within 322 km (200 mi) of NEF Site



0 50 100 200 Miles

0 80 160 320 Kilometers

NOTE: Locations of nearest capable faults (red traces) and older faults (blue traces)

LOCATIONS OF NEAREST FAULTS TO THE NEF SITE

Figure 3.2-36 Locations of Nearest Faults to the NEF Site

3.3 FACILITY DESCRIPTION

The arrangement of the National Enrichment Facility (NEF) is shown in Figure 3.3-1, Facility Buildings and Areas. The major structures and functional areas of the facility are discussed in the following sections.

Distances from the facility to the site boundary were determined using guidance from U.S. NRC Regulatory Guide 1.145 (NRC, 1982), i.e., the nearest point on the building complex to the site boundary within a 45-degree sector centered on the compass direction of interest. These distances are provided in Table 3.3-1, Distances to Site Boundary and to Restricted Area Boundary and Wind Frequencies.

The distance to the nearest resident is greater than 4.26 km (2.63 mi).

3.3.1 Buildings and Major Components

3.3.1.1 Separations Building Modules (SBMS)

3.3.1.1.1 Design Description

The overall layout of Separations Building Module 1001 (SBM-1001) is presented in Figures 3.3-2 through 3.3-5. The overall layout of SBM-1003 is presented in Figures 3.3-6 through 3.3-9. The SBMs have two Cascade Halls, a UF_6 Handling Area, and a Process Services Corridor.

3.3.1.1.2 Functional Areas and Major Components

3.3.1.1.2.1 Cascade Halls

The Cascade Halls contains multiple cascades, each of which is made up of many centrifuges. Structural support walls split the Cascade Hall into Mini-Halls. The centrifuges are mounted on precast concrete floor mounting elements (flomels). Each Mini-Hall is enclosed by a structural steel frame, which supports insulated thermal sandwich panels. These panels surround each Mini-Hall to aid in maintaining a constant temperature within the enclosure. A temporary Mobile Thermal Wall System separated operating cascades from construction and installation of subsequent cascades in the same Mini-Hall.

3.3.1.1.2.2 Process Services Corridor

(See SAR § 12.2.1.1.1) The Process Services Corridor contains gas transport equipment, which connects the cascades to the UF_6 Feed System, Product Take-off System, Tails Take-off System and Contingency Dump System.

All three floors of the Process Services Corridor contains various pieces of equipment, control cabinets and electrical cabinets. In addition the second floor contains valve support frames, process pumps and chemical traps and the third floorcontains water pumps and heating and ventilation equipment. The various floors of the Process Services Corridor can be accessed by one of three stairways or by the freight elevator.

3.3.1.1.2.3 UF_6 Handling Area

The UF_6 Handling Area contains the UF_6 Feed System, Product Take-off System, Tails Take-off System, and Product Blending and Liquid Sampling System.

From the Feed System, natural uranium in the form of UF_6 is fed into the cascades. The Product Take-off System collects UF_6 enriched in the ^{235}U isotope while the Tails Take-off System normally collects UF_6 depleted in the ^{235}U isotope. Under abnormal process conditions the Tails Take-off will accept the contents of dumped cascades.

(See SAR § 12.2.1.1.2 and 12.2.1.1.3) The primary function of the Product Blending and Liquid Sampling System is to provide means to fill 30B product cylinders with UF_6 at a required ^{235}U concentration and to obtain homogenized liquid UF_6 samples. The Blending and Liquid Sampling Area (BLSA) contains the major components associated with the Product Blending System and the Product Liquid Sampling System. The Product Blending System is described in Section 3.4.6, Product Blending System. The Product Liquid Sampling System is described in Section 3.4.7, Product Liquid Sampling System. The UF_6 cylinders used in the autoclaves are protected from tornado missiles either by hardened structure around the autoclaves or by the design of the autoclave itself.

(See SAR § 12.2.1.1.4) Rail transporters travel on rails embedded along the entire width of the UF_6 Handling Area floor. The rail transporter transfers 30B and 48Y cylinders to and from the appropriate feed, feed purification, tails, or blending station, or product sampling autoclaves.

3.3.1.1.3 Building Construction

Each SBM superstructure is structurally independent from adjacent superstructure(s). Interior non-load bearing walls are constructed of concrete block with a painted finish. These walls extend to the underside of the structure where required.

The floors of the Cascade Halls have a floor profile quality classification of flat in accordance with American Concrete Institute (ACI) 117 to aid in the transport of assembled centrifuges.

Cascade Hall and UF_6 Handling Area floors are exposed concrete with a washable epoxy coating finish designed to resist process chemicals, decontamination agents and radiation.

3.3.1.2 Technical Services Building

The overall layout of the Technical Services Building (TSB) is presented in Figures 3.3-10and 3.3-11. The TSB is located adjacent to the CRDB. The TSB contains support areas for the facility. It also acts as a point of entry to the CRDB.

3.3.1.2.1 Design Description

The TSB is a two-story structure and totals approximately 5730 m^2 (61,700 ft^2) per floor. The classification of the TSB includes a mixture of uses including B, S, F and H occupancy. The majority of the Building is classified as Group B. The TSB is classified as a Type II-B Construction by the NMCBC and as a Type II (000) Construction by NFPA 220.

Several of the TSB areas are separated from adjacent areas by one-hour or greater fire-rated construction. These areas include:

- Chemical Storage and Waste Processing
- I&C Electrical Shop
- Mechanical Shop
- Warehouse

3.3.1.2.2 Functional Areas and Major Components

3.3.1.2.2.1 Control Room

The Control Room is the main monitoring and reporting point for the entire facility. The Control Room provides facilities to both directly and indirectly monitor and operate plant control systems. It is classified as a B Occupancy. It is a permanently manned area and contains the following equipment:

- Overview screen
- Control desk
- Fire alarm system
- Plant Control Systems
- Communication systems.

The Plant Control Systems and the Communications and Alarms System are described in Section 3.5.9, Control Systems and Section 3.5.7, Communication and Alarm Annunciation Systems, respectively.

3.3.1.2.2.2 Training Rooms

Several training rooms are available for Operational training. The rooms are classified as B Occupancy areas. The rooms are in the hardened area and contain the following:

- Plant Control System training system
- Centrifuge Monitoring System training system
- Central Control System switches and servers

3.3.1.2.2.3 Central Alarm Station (CAS) Area

The Central Alarm Station Area is used as the primary security monitoring station for the facility. The area includes the Central Alarm Station (CAS), offices, conference area and secure file storage area. It is classified as a B Occupancy area. All electronic security systems are controlled and monitored from this center. These systems include Closed Circuit Television (CCTV), Intrusion Detection and Assessment (IDA), Access Control and Radio Dispatch. The Secondary Alarm Station (SAS) is located in the Security Building and serves as a duplicate control console to the CAS.

3.3.1.2.2.4 Medical Room

(See SAR § 12.2.1.2.1) The Medical Room is designed to provide space for a nurse's station. This room is classified as a B Occupancy area.

3.3.1.2.2.5 Emergency Operations Center (EOC) Area

The Emergency Operations Center Room serves as an assembly area for emergency planning purposes. The EOC is classified as a B Occupancy area and has a general assembly room, offices and a meeting room.

3.3.1.2.2.6 Technical Support Center Assembly Room

The Technical Support Center Assembly Room serves as an assembly area for emergency planning purposes and has an area allocated for the storage of emergency equipment and supplies. It is classified as a B Occupancy area.

3.3.1.2.2.7 Break Room

(See SAR § 12.2.1.2.2) The Break Room has space for vending machines, tables and a small kitchenette. It is classified as a B Occupancy area.

3.3.1.2.2.8 I&C Electrical Shop Room

(See SAR § 12.2.1.2.3) The I&C Electrical Shop Room serves as a work area for general electrical and I&C components and maintenance. This room is classified as a F-2 Occupancy area.

3.3.1.2.2.9 Mechanical Shop Room

(See SAR § 12.2.1.2.4) The Mechanical Shop Room serves as a work area for general mechanical maintenance and work such as painting or welding. This room classified as a F-1 Occupancy area.

3.3.1.2.2.10 Chemical Storage Room

The Chemical Storage Room serves as a storage area for typical industrial chemicals. This room is classified as an H-1 Occupancy area.

3.3.1.2.2.11 Waste Processing Room

(See SAR § 12.2.1.2.5) The Waste Processing Room serves as a processing area of non radioactive wastes. This room is classified as a F-1 Occupancy area.

3.3.1.2.2.12 Environmental Monitoring Laboratory

(See SAR § 12.2.1.2.6) The Environmental Monitoring Laboratory is designed for preparing and analyzing samples associated with safety or regulatory compliance. This room is classified as a F-1 Occupancy area.

3.3.1.2.3 Building Construction

The TSB structure is a pre-engineered steel frame building with non-combustible construction throughout. The building is divided into two distinct areas referred to as Hardened and Non-Hardened areas. These two portions of the building are designed to be structurally independent of one another.

The Hardened area is completely enclosed by a tilt-up concrete panel system and cast-in-place roof slab, designed to resist tornado forces without failure. The exterior finish system of this portion of the building consists of metal building panels over insulation board.

The Non-Hardened area is a standard pre-engineered steel frame system with horizontal steel girt members, steel roof purlins and metal panel exterior walls and roof.

3.3.1.3 Cylinder Receipt and Dispatch Building (CRDB)

The overall layout of the CRDB is presented in Figures 3.3-12 and 3.3-13. The CRDB is located between two Separations Building Modules and directly north of the Technical Services Building.

3.3.1.3.1 Design Description

The CRDB is a one story building with a two story interior Bunkered Area. The CRDB utilizes steel frame and steel panel construction. The Bunkered Area inside the CRDB is comprised of reinforced poured concrete. The CRDB is approximately 240.3 m (788 ft) long, 48.1 m (158 ft) wide, and 14.8 m (48.5 ft) high (at the eave) and totals an area of 15,123 m^2 (162,782 ft^2) (including the 2nd floor of the Bunkered Area) . It is classified as an H-4 Occupancy area by the New Mexico Commercial Building Code (NMCBC). It is classified as a Type I-B Construction by the NMCBC and as a Type II (222) Construction by NFPA 220. The CRDB is separated from the TSB by three-hour fire-rated construction.

3.3.1.3.2 Functional Areas and Major Components

UF_6 (48Y) feed and uranium byproduct (UBC or tails) cylinders and (30B) product cylinders are received and dispatched by the facility through the CRDB. It is designed to include space for the following:

Outside the CRDB's Bunkered Area:

- Loading and unloading of cylinders
- Inventory weighing
- Preparation and storage of protective cylinder overpacks
- Buffer storage of feed cylinders
- Semi-finished product storage
- Final product storage
- Prepared cylinder storage
- Staging (temporary storage) of tails and empty feed cylinders.

Inside the CRDB's Bunkered Area:

- Equipment decontamination
- Rebuilding of vacuum pumps
- UF_6 cylinder valve repair
- Solid waste collection and packaging
- Collection and treatment of liquid effluents

- Contaminated Material Handling-
- Mass spectrometry and chemical analysis
- Radiation monitoring
- Filtration and exhaust of gaseous effluent through Gaseous Effluent Vent Systems (GEVSs)
- HVAC equipment (supporting radiological and non-radiological portions of the CRDB)

Inside the CRDB steel butler building, there is an inner, two story stand-alone concrete structure referred to as the "Bunkered Area." Inside the CRDB Bunkered Area, the following functional areas are located on the ground floor:

- Ventilated Room (Room 143)
- Decontamination Workshop (Room 151)
- Vacuum Pump Rebuild Workshop (Room 154)
- Vacuum Pump Test Room (Room 155)
- Liquid Effluent Collection and Treatment Room (Room 156)
- Solid Waste Collection Room (161)
- Mass Spectrometry Laboratory (Room 136)
- Chemical Laboratory (Room 133)
- Sample Storage (Room 139)

Also inside the CRDB Bunkered Area, the following functional areas are located on the second floor:

- Gaseous Effluent Vent System (GEVS) Room (Room 242)
- Contaminated material handling Room (Room 261)
- Radiation Monitoring Laboratory (Room 262)

3.3.1.3.2.1 Solid Waste Collection Room

(See SAR § 12.2.1.3.1) The Solid Waste Collection Room is designed to process both wet and dry low-level radioactive solid waste. The Solid Waste Collection System is described in Section 3.5.13, Solid Waste Collection. Wet waste is categorized as radioactive, hazardous or industrial waste and includes assorted materials, oil recovery sludge, oil filters and miscellaneous hazardous wastes. Dry waste is also categorized as radioactive, hazardous or industrial waste and includes assorted materials, activated carbon, activated aluminum oxide, activated sodium fluoride, HEPA filters, scrap metal and miscellaneous hazardous materials.

This room contains approximately 288 m^2 (3,100 ft^2). It is classified as an H-4 Occupancy area. This area is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.2 Vacuum Pump Rebuild Workshop

(See SAR § 12.2.1.3.2) The Vacuum Pump Rebuild Workshop is designed to provide space for the maintenance and re-building of plant equipment, mainly pumps which have been decontaminated in the Decontamination Workshop, and other miscellaneous plant equipment.

This room contains approximately 334.5 m^2 (3,600 ft^2). The workshop consists of an open area, a storage area and a data logging/progress chasing area. It is equipped with suitable area lighting, a degassing oven, heating, ventilating, and air conditioning (HVAC), CRDB GEVS, vacuum systems and a spray booth with a filter and extraction system. It is classified as an H-4 Occupancy area. This area is separated from the other adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.3 Decontamination Workshop

(See SAR § 12.2.1.3.3.) The purpose of the Decontamination Workshop is to provide a maintenance facility for both UF_6 pumps and vacuum pumps. It is also used for the temporary storage and subsequent dismantling of failed pumps. The activities carried out within the Decontamination Workshop include receipt and storage of contaminated pumps, out-gassing, Perfluorinated Polyether (PFPE) oil removal and storage, pump stripping, and the dismantling and maintenance of valves and other plant components.

The Decontamination Workshop also provides a facility for the removal of radioactive contamination from contaminated materials and equipment. The Decontamination process consists of a series of steps including equipment disassembly, degreasing, decontamination, drying and inspection. Components commonly decontaminated include pumps, valves, piping, instruments, sample bottles, tools and scrap metal. The Decontamination System is described in Section 3.5.14, Decontamination Workshop.

The Decontamination Workshop is maintained at a lower pressure than any non-radiological surrounding areas. Therefore any equipment or personnel entering this room must go through an air-lock. For emergencies other emergency egress doors are provided.

This room contains approximately 362.3 m^2 (3,900 ft^2). It is classified as an H-4 Occupancy area. This area is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.4 Ventilated Room

(See SAR § 12.2.1.3.4) The Ventilated Room is designed to provide space for the maintenance of chemical traps and cylinders. The Ventilated Room is also used for the temporary storage of full and empty chemical traps and the contaminated chemicals used in the chemical traps.

The activities carried out within the Ventilated Room include receipt and storage of saturated chemical traps, chemical removal and temporary storage, contaminated cylinder pressure testing, and UF_6 cylinder pump out and valve maintenance.

The Ventilated Room is maintained at a lower pressure than any non-radiological surrounding areas. Therefore, any equipment or personnel entering this room must go through an air-lock. For emergencies other emergency egress doors are provided.

Cylinders received at the site are expected to be in good working condition. Cylinders with deficient conditions are returned to an approved supplier for corrective maintenance and testing in accordance with ANSI N14.1-2001, provided the cylinder fully complies with all DOT transport requirements.

Cylinders with deficient conditions that do not fully comply with all DOT transport requirements must be corrected at the site. Such corrective maintenance may include valve replacement, plug replacement and post maintenance testing on containers with UF_6. Such corrective maintenanct and testing is performed in the CRDB Ventilated Room in accordance with ANSI N14.1-2001 and the LES QA Program.

This room contains approximately 297.3 m^2 (3,200 ft^2). It is classified as an H-4 Occupancy area. This area is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.5 Liquid Effluent Collection and Treatment Room

The Liquid Effluent Collection and Treatment Room is designed for the collection of potentially contaminated liquid effluents produced on site, which are monitored for contamination prior to processing. These liquid effluents are stored in tanks prior to processing. The effluents are segregated into significantly contaminated effluent, slightly contaminated effluent or non-contaminated effluent. Liquid effluents produced by the facility include hydrolysed uranium hexafluoride and aqueous laboratory effluent, degreaser water, citric acid, floor washings, miscellaneous condensates, and active area hand washings/shower water. The Liquid Waste Collection System is described in Section 3.5.12, Liquid Effluent Collection and Treatment System. The LECTS Room will also be used for trap filling.

This room contains approximately 323.2 m^2 (3,480 ft^2). It is classified as an H-4 Occupancy area. The Liquid Effluent Collection and Treatment Room is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.6 Contaminated Material Handling Room

(See SAR § 12.2.1.3.6) The Contaminated Material Handling Room, located in the CRDB, provides an area for the Recycling Group to store protective clothing drums and other material/waste containers that have been assayed and released from the Safeguards item control program. This area will normally provide storage for containers awaiting Radiation Protection survey to be either unconditionally released or transferred to the solid waste collection system for additional processing. In addition, the Contaminated Material Handling Room will contain cabinets and bins with supplies to support the waste program and a connection to the CRDB GEVS to support ventilation engineering controls when required.

This room contains approximately 46.4 m^2 (500 ft^2). It is classified as an H-4 Occupancy area. The Contaminated Material Handling Room is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.7 Gaseous Effluent Vent System (GEVS) Room

(See SAR § 12.2.1.3.7) The GEVS Room is located in the second floor of the CRDB's Bunkered Area, and contains the fan/filters systems and other major components for the CRDB GEVS. This GEVS is designed to remove UF_6, particulates containing uranium, and HF from potentially contaminated process gas streams. Pre-filters and HEPA filters remove particulates, including uranium particles, and impregnated activated charcoal filters remove any residual traces of uranium and HF. The GEVS are described in Section 3.4.9, Gaseous Effluent Vent Systems (GEVS).

This room contains approximately 355 m^2 (3,820 ft^2). It is classified as an H-4 Occupancy area and is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.8 Mass Spectrometry Laboratory

(See SAR § 12.2.1.3.8) The Mass Spectrometry Laboratory is designed for the purpose of measuring the isotopic abundance of various uranium isotopes in prepared samples, the bulk comprising hydrolysed uranium hexafluoride.

This room contains approximately 167.2 m^2 (1,800 ft^2). It is classified as an H-4 Occupancy area and is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.9 Chemical Laboratory

(See SAR § 12.2.1.3.9) The Chemical Laboratory is designed for the purpose of analyzing solid and liquid samples taken from all areas of the facility. It includes space for an analytical area, sub sampling area, wash area and weighing area, and a sample storage area.

This room contains approximately 257.8 m2 (2,775 ft2). It is classified as an H-4 Occupancy area and is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.10 Radiation Monitoring Laboratory

(See SAR § 12.2.1.3.10) The Radiation Monitoring Laboratory is designed to be the point of demarcation between non-contaminated areas and potentially contaminated areas of the facility. It includes space for a hand and foot monitor, hand washing facilities, safety showers, and boot barrier access.

This room contains approximately 55.7 m^2 (600 ft^2). It is classified as an H-4 Occupancy area and is separated from adjacent areas by two-hour fire-rated construction.

3.3.1.3.2.11 Truck Bay/Shipping and Receiving Area

(See SAR § 12.2.1.3.11) The Truck Bay, located at the North end of the CRDB, is used for the receipt of incoming and the dispatch of outgoing UF_6 (48Y) feed and tails cylinders, UF_6 (30B) product cylinders, and overpacks for 30Bs. The Truck Bay is also used as a place to load packaged low-level radioactive wastes onto trucks for transportation off site to a licensed processing facility or licensed disposal facility. It is also used for miscellaneous shipping and receiving.

This area is approximately 35.2 m (115.5 ft) x 47.5 m (156 ft) and totals 1,672 m2 (18,018 ft2). It is classified as an H-4 Occupancy area.

3.3.1.3.2.12 Cylinder Storage Areas

(See SAR § 12.2.1.3.12) The majority of the floor area is used as lay-down space for cylinders of all types. The cylinders are placed on specially designed cradles to stabilize them while being stored in the CRDB.

Cylinders are delivered to the facility in transport trucks. The trucks enter the CRDB through the main vehicle loading bay, located at the North end of the building, which is equipped with vehicle access platforms that aid with cylinder loading and unloading. Three double girder bridge cranes on two sets of crane rails handle the cylinders within the CRDB. Each crane spans half the width of the CRDB. The two bridge cranes on the West side run the full length of the building. The third bridge crane on the East side services the area North of the Bunkered Area.

After delivery, the cylinders are processed for receipt. They are inspected and weighed and moved to their appropriate locations. UF_6 feed cylinders are delivered to a storage area in the CRDB or to a storage area in the UBC Storage Pad.

When required for processing, the cylinders, which have been placed in storage areas are moved by the overhead cranes to the stillages and rail transporter located in the cylinder transporting and stillage area at the South end of the CRDB. The rail transporter moves cylinders from the CRDB to the adjacent SBM UF_6 handling areas. Cylinders are removed from the facility in the same fashion.

3.3.1.3.3 Building Construction

The CRDB superstructure will consist of a QA Level-1 (Graded) steel building shell, with a separate and seismically independent interior Bunkered Area that meets all QA Level-1 requirements. The building is divided into two distinct areas referred to as the Bunkered Area and the Non-Bunkered area (also referred to as CRDB steel building or CRDB building shell). These two portions of the building are designed to be structurally independent of one another.

The CRDB superstructure (Non-Bunkered Area) is a standard pre-engineered steel frame building with horizontal steel girt members, steel roof purlins, metal panel exterior walls and roof, with non-combustible construction throughout. The building shell is designed to withstand the effects of external events (i.e., seismic, tornado and high wind, snow and ice load, and maximum local precipitation and flooding) as reflected in Section 3.2, except tornado missiles. It is considered acceptable if the metal wall and roof panels separate from the steel superstructure under extreme tornado wind conditions. The CRDB superstructure is not required to provide missile protection or to prevent water intrusion. The floor of each area consists of a 20.3 cm (8") reinforced concrete slab. Floor areas where rails systems are emplaced for the transport of UF_6 cylinders consist of a 61 cm (24") reinforced concrete slab.

To assure adequate structural design margin against collapse of the superstructure under these conditions, the CRDB superstructure will be designed in accordance with the AISC ASD Manual of Steel Construction and ACI 318, Building Code Requirements for Structural Concrete. In addition, the building design analyses will be performed in accordance with accepted industry standards, including ASCE 4, Seismic Analysis of Safety-Related Nuclear Structures, and ASCE 7, Minimum Design Loads for Buildings and Other Structures. The CRDB superstructure design will be verified per QL-1 requirements and designated a QL-1G program. Construction of the CRDB structure will be in accordance with the graded QL-1 program described in the QAPD. These design and quality requirements will provide a substantial margin of safety against collapse.

The Bunkered Area is a two-story structure that is completely enclosed by a poured in place concrete foundation, floors, walls, and cast-in-place roof slab. The first floor of each area consists of a 20.3 cm (8") reinforced concrete slab. Floor areas where rails systems are emplaced for the transport of UF_6 cylinders in the Ventilated Room and an adjacent airlock consist of a 61 cm (24") reinforced concrete slab. The second floor consists of a 15.2 cm (6") to 20.3 cm (8") reinforced concrete floor slab. The roof system of the Bunkered Area consists of a 20.3 cm (8") reinforced concrete roof slab. The CRDB Bunkered Area is designed to withstand the effects of external events (i.e., seismic, tornado and high wind, tornado missiles, snow and ice load, maximum local precipitation, and flooding) as reflected in Section 3.2. The design and construction of the Bunkered Area will be in accordance the QA Level 1 (QL-1) program.
The three double girder bridge cranes on two sets of rails that serve the CRDB are supported by steel columns anchored to the foundation adjacent to the main building support columns.

The floor areas of the CRDB, which are used as a part of the centrifuge transport path, have a floor profile quality classification of flat in accordance with DIN 18202 (Table 3, Line 4), to aid in the transport of assembled centrifuges. According to DIN 18202 the surface profile shall not deviate more than 3 mm per meter in length.

Floors in the CRDB are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.4 Centrifuge Assembly Building (CAB)

The overall layout of the Centrifuge Assembly Building (CAB) is presented in Figures 3.3-14 and 3.3-15. The Centrifuge Assembly Building is located adjacent to the CRDB.

3.3.1.4.1 Design Description

The CAB is a steel frame building with insulated metal panel exterior walls and with built-up roofing on metal deck roof.

The CAB is used for assembly, inspection and mechanical testing of the centrifuges prior to installation in the SBM Cascade Halls. For protection of CAB investments (centrifuges and equipment) against the deleterious effects of airborne contaminations, centrifuge assembly activities are performed in clean conditions per the guidelines of ISO 14644-1 class 8; operational state. The building is divided into the following distinct areas:

- Centrifuge Component Storage Area
- Centrifuge Assembly Area 'A'
- Centrifuge Assembly Area 'B'
- Centrifuge Assembly Area 'C'
- Assembled Centrifuge Storage Area
- Building Office Area
- Centrifuge Test and Post Mortem Facilities
- Electrical rooms on the South, East and West sides
- Air compressor room South side

3.3.1.4.2 Functional Areas and Major Components

3.3.1.4.2.1 Centrifuge Component Storage Area

The Centrifuge Component Storage Area serves as the initial receipt location for the centrifuge parts. It is designed to store up to four weeks stock of centrifuge components . These components are delivered by truck in specifically designed containers, which are then packed into International Organization for Standardization (ISO) freight containers. The containers are off-loaded via fork lift truck and placed in the storage area through one of two roll up doors located at the east end of the CAB.

The Centrifuge Component Storage Area acts as an acclimatization area to allow components to equilibrate with the climatic conditions of the Centrifuge Assembly Area.

Transfer of components and personnel between the Centrifuge Component Storage Area and the Centrifuge Assembly Areas is via an airlock to prevent ingress of airborne contaminants.

3.3.1.4.2.2 Centrifuge Assembly Areas

Centrifuge components are assembled into complete centrifuges in these areas. Prior to installation into the cascade, the centrifuge has to be conditioned, which is done in the Centrifuge Assembly Areas prior to storage in the Assembled Centrifuge Storage Area.

A separate installation team will access this area and transfer the assembled and conditioned centrifuges to the Cascade Halls for deployment.

3.3.1.4.2.3 Building Office Area

A general office area is located adjacent to the Centrifuge Assembly Area. It contains the main personnel entrance to the building as well as entrances to the Centrifuge Component Storage Area and Centrifuge Assembly Area. It is a two-story area that includes the following:

- Offices
- Locker Rooms - The locker rooms provide space where employees can dress in protective clothing as required
- Canteen
- Two Computer Server Rooms
- Maintenance Area
- Inspection and Test Laboratory
- Air Locks
- Air Compressor Room – (one of two: the other air compressor room is located on the South side of the CAB)
- An Elevator

3.3.1.4.2.4 Centrifuge Test and Post Mortem Facilities

The Centrifuge Test Facility is designed to:

- Provide a means of functionally testing the performance of production centrifuges to ensure compliance with design parameters
- Investigate production and operational problems.
- Test either a single centrifuge or two simultaneously

The Centrifuge Post Mortem Facility is designed for investigating problems with production centrifuges. Based on 30 years of European experience, the demand for centrifuge post mortems is infrequent.

The principal functions of the Centrifuge Post Mortem Facility are:

- To facilitate dismantling of contaminated centrifuges using equipment and processes, which minimize the potential to contaminate personnel or adjacent facilities
- To prepare potentially contaminated components and materials for transfer prior to disposal.

Centrifuges are brought into the facility on a specially designed transport cart . The facility is also equipped with radiological monitoring devices, toilets and washing facilities, and hand, foot and clothing personnel monitors to detect surface contamination.

The Centrifuge Post Mortem Facility includes a centrifuge dismantling area and an inspection area. The centrifuge dismantling area includes a stand onto which the centrifuge to be dismantled is mounted providing access to the top and bottom of the centrifuge. A local jib crane is located over the stand to enable removal of the centrifuge from the transport cart and facilitate loading onto the stand. The inspection area includes an inspection bench, portable lighting, a microscope, an endoscope and a digital video/camera.

3.3.1.4.3 Building Construction

The CAB is a metal building that is constructed on a concrete slab. The floors of the CAB Assembled Centrifuge Storage Area have a floor profile quality classification of flat in accordance with ACI 117 to aid in the transport of assembled centrifuges.

Floors in the CAB (except for certain office areas) are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.5 Not Used

3.3.1.6 (See SAR § 12.2.1.4) Uranium Byproduct Cylinder (UBC) Storage Pad

The facility utilizes an area outside of the CRDB for storage of UBCs, which contain UF_6 that is depleted in ^{235}U. The tails are stored under vacuum in corrosion resistant Type 48Y cylinders. The UBC Storage Pad will also be used for buffered storage of full and empty feed (48Y) cylinders and clean, empty product (30B) cylinders. In fair weather the UBC Storage Pad can be used for material receipt. The UBC Storage Pad is shown on Figure 3.3-1, Facility Buildings and Areas.

3.3.1.6.1 Design Description

The UBC Storage Pad is designed to provide storage for UBCs and full production buffered storage of approximately:

- 24 months stock of full feed cylinders,
- 24 months supply of empty feed cylinders, and
- 12 months supply of clean, empty product cylinders.

Approximately 625 UBC per year are filled for storage. The UBC Storage pad is sized to accommodate 15,727 cylinders (capacity equivalent to 25 years of facility operation). These cylinders are stacked two high. Cradles are used to store the cylinders approximately 200 mm (8 in) above ground level. The UBC Storage Pad is constructed in approximately 112,000 sq. ft. (2.6 acre) sections throughout the operating life of the facility to ensure sufficient cylinder storage capacity.

3.3.1.6.2 Functional Areas and Major Components

The UBC Storage Pad layout is based on moving the cylinders with mobile gantry cranes and powered vehicles. Powered vehicles are used to move the cylinders from the CRDB to the UBC Storage Pad. A single girder mobile gantry crane is used to remove the cylinders from the powered vehicles and place them in the UBC Storage Pad. The mobile gantry crane is designed to double stack the cylinders in the storage area. When feed or product cylinders exit the UBC Storage Pad, the mobile gantry crane and powered vehicles are used to move the cylinders.

3.3.1.6.3 Construction

The UBC Storage Pad is constructed of a concrete pad with a dedicated collection and drainage system. Access to the UBC Storage Pad is controlled by the site perimeter fence and in accordance with IROFS 36e, 50a and 50h.

3.3.1.7 (See SAR § 12.2.1.5) Central Utilities Building (CUB)

The Central Utilities Building (CUB) is shown on Figure 3.3-16.

3.3.1.7.1 Design Description

The CUB has an approximate total area of 3044 m^2 (32,766 ft^2). It is classified as a F-1 Occupancy area by the New Mexico Commercial Building Code (NMCBC). It is classified as a Type II-B Construction by the NMCBC and as a Type II (000) Construction by NFPA 220. The Central Utilities Building is designed to meet the occupant and exiting requirements set by the International Fire Code and the NMCBC.

3.3.1.7.2 Functional Areas and Major Components

The Central Utilities Building houses two diesel generators, which provide the site with standby power. The Standby Generator System is discussed in Section 3.5.10, Standby Diesel Generator System. The building contains day tanks, switchgear, and control panels. The rooms housing the diesels are constructed independent of each other with adequate provisions made for maintenance, equipment removal and equipment replacement.

The diesel fuel unloading area provides tanker truck access to the two above ground tanks, which provide diesel fuel storage. Secondary containment is provided to contain spills or leaks from the above ground diesel fuel tanks.

The CUB also houses the centrifuge cooling water pumps and air compressors. These systems are described in Sections 3.5.5, Cooling Water System and 3.5.3, Compressed Air System, respectively.

3.3.1.7.3 Building Construction

The CUB superstructure is cast in place concrete construction with shear walls and pilasters that support steel framing for roof slabs.

The CUB roof structure consists of concrete slabs poured over steel decking supported by wide flange beams (purlins). Rigid insulation and multi-ply composite roofing system is installed atop the concrete roof slab. The roof assembly will have a minimum combined thermal resistance of R-20.

Exterior and interior walls will be cast-in-place concrete load bearing shear walls. Exterior walls will have a minimum combined thermal resistance value of R-10.

Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with a painted finish. These interior walls extend to the underside of the structure where required.

Floors consist of exposed concrete with a washable epoxy coating finish.

3.3.1.8 (See SAR § 12.2.1.6) Administration Building

3.3.1.8.1 Design Description

The Administration Building is near the TSB. It is over 3,000 m2 (32,000 ft2) and 6.0 m (19.8 ft) high. It is classified as a B Occupancy area by the New Mexico Commercial Building Code (NMCBC). It is classified as a Type II-B Construction by the NMCBC and as a Type II (000) Construction by NFPA 220. The Administration Building is designed to meet the occupant, and exiting requirements set by the International Fire Code and the NMCBC. The entire building is sprinklered.

3.3.1.8.2 Functional Areas and Major Components

The general office areas for the facility are located in the Administration Building. Personnel enter the Administration Building and general office areas via the main lobby.

Over 50 work locations are provided for the plant office staff. The office environment consists of private, semiprivate, and open office space. The lobby is designed to also act as an assembly area for emergency planning purposes. Area has been allocated for the storage of emergency equipment and supplies and emergency monitoring equipment. It also contains a kitchen, break room, conference rooms, and building service facilities such as a mechanical equipment room. An open office layout allows for flexibility in space allocation.

3.3.1.8.3 Building Construction

The Administration Building superstructure is designed of structural steel framing.

The roof structure consists of metal decking over structural steel framing. The metal decking is covered with a built-up roof system. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls consist of a combination of architectural metal panels and a curtain wall glazing system. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is faced with 16 mm (5/8 in) gypsum wallboard.

Interior non-load bearing walls are constructed of 92 mm (4 in) metal studs filled with batt insulation and faced with 16 mm (5/8 in) gypsum wallboard. Walls extend to 150 mm (6 in) above the ceiling or to the underside of the structure where required.

3.3.1.9 (See SAR § 12.2.1.7) Site Security Buildings

3.3.1.9.1 Design Description

The main Security Building is located at the entrance to the facility. It functions as a security checkpoint for incoming and outgoing personnel. Employees and visitors that have access approval are screened at the main building. A smaller Gatehouse has been placed at the secondary site entrance. Vehicle traffic including common carriers, such as mail delivery trucks, are screened at this location.

The main Security Building also contains the Visitor Center. There are adequate physical barriers, locked doors, etc to separate the visitor accessible areas from areas designed to support the security.

3.3.1.9.2 Functional Areas and Major Components

3.3.1.9.2.1 Main and Secondary Security Buildins

The main and secondary Security Buildings are located at the entries to the site. They are classified as a B Occupancy area by the New Mexico Commercial Building Code (NMCBC). It is classified as a Type II-B Construction by the NMCBC and as a Type II (000) Construction by NFPA 220.These buildings are designed to meet the occupant and exiting requirements set by the International Fire Code and the NMCBC.

The Entry Exit Control Point (EECP) for the facility is located in the main Security Building. All personnel access to the facility occurs at this location. Vehicular traffic passes through a security checkpoint before being allowed to park. Parking is located outside of the Controlled Access Area (CAA) security fence.

Personnel requiring access to facility areas or the CAA must pass through the EECP. The EECP is located at the rear of the main lobby and is designed to facilitate and control passage of authorized facility personnel and visitors to and from the CAA. Personnel entering the security Controlled Access Area are required to undergo, at a minimum, the following security screening at the EECP:

- Positive Identification – photo badge and/or biometrics
- Verification of access authorization
- Inspection of persons for unauthorized material (pass through a magnetometer)
- Inspection of all hand carried packages (x-ray screening).

In the main lobby, employees receive their badges and proceed through a turnstile into the office area or the EECP. Visitors check-in at the main lobby, where a receptionist notifies plant personnel of their arrival.

Entry to the facility areas from the Security Building is only possible through the EECP.

3.3.1.9.2.2 Security Diesel Generator

The Security Diesel Generator provides backup 480 volt power to select security and security related equipment during a loss of normal power. The Security Diesel Generator is not a requirement for safe operation of the plant. The Security Diesel Generator is designed for outdoor use and is located south of the TSB within a walled enclosure to reduce accessibility, but it is otherwise open to the environment. The fuel oil storage capacity tank is sized for 24 hours of continuous operation at 100% rated power output.

3.3.1.9.3 Building Construction

The Security Building superstructures are designed of structural steel framing.

The roof structures consist of metal decking over structural steel framing. The metal decking is covered with a built-up roof system. The roof assembly has a minimum thermal resistance value of R-20.

Exterior walls consist of a combination of architectural metal panels and glazing. Exterior wells meet the requirements of the New Mexico Energy Conservation Code at a minimum. The interior side of the exterior wall is faced with 16 mm (5/8 in) gypsum wallboard.

Interior non-load bearing walls are constructed of metal studs filled with batt insulation and faced with 16 mm (5/8 in) gypsum wallboard.

Floors in the Security Buildings consist of carpet, tile, and concrete.

3.3.2 Structural Design Criteria

The structural and mechanical design load criteria are based on the environmental and geologic features of the National Enrichment Facility site identified in Section 3.2, Site Description, and the data presented in the accepted Industry Codes and Standards. The design criteria meets the applicable baseline design criteria established in 10 CFR 70.64, Requirements for new facilities or new processes at existing facilities (CFR, 2003). The design is based on the codes and loads described below.

As part of the Integrated Safety Analysis for external events, the following structures (buildings and areas) were determined to be safety significant and are required to withstand the design basis natural phenomena hazards and external hazards defined in Section 3.2, with exceptions as noted below:

- The Separations Building Modules UF_6 Handling Area, Process Services Corridor, and Cascade Halls are IROFS27e and are not required to meet the requirements of ASCE 43-05.
- The Cylinder Receipt and Dispatch Building Shell is IROFS27e and is not required to meet the requirements of ASCE 43-05.

Safety significant structures shall be designed to withstand the effects of external events (i.e., seismic, tornado and high wind, tornado missiles, snow and ice load, and maximum local precipitation) reflected in Section 3.2. (See Section 3.3.2.2.3.2 for exceptions related to tornado missiles.)

The liquid UF_6 cylinders in the autoclaves are protected from tornado missiles either by hardened structure around the autoclaves or by the design of the autoclave itself.

Above ground liquid storage tanks and water impoundments shall be designed such that they do not pose a flooding risk that could damage critical structures and/or systems under an assumed catastrophic failure and release of full contents (may be shown either by design, amount of contents or physical location).

Items relied on for safety (IROFS) associated with facility structures are listed in Section 3.8, IROFS.

3.3.2.1 Codes and Standards

The following codes and standards are generally applicable to the structural design of the National Enrichment Facility:

- New Mexico Commercial Building Code
- International Building Code
- ASCE 7, Minimum Design Loads for Buildings and Other Structures
- ACI 318, Building Code Requirements for Structural Concrete
- ACI 349, Code Requirements for Nuclear Safety Related Concrete Structures
- AISC Manual of Steel Construction
- ANSI/AISC N690, American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities
- PCI Design Handbook
- American Society of Testing and Materials.

3.3.2.2 Structural Design Loads

3.3.2.2.1 Wind Loadings

"Wind loadings for structures are in accordance with provisions of the International Building Code and Section 6.5 of ASCE 7. The annual probability of recurrence for wind loadings used in designing Safety Significant Structures cannot be greater than 1.0 E-5."

3.3.2.2.2 Cyclonic Loadings

3.3.2.2.2.1 Tornado

The safety significant structures and components exposed to wind are designed to withstand tornado loadings including tornado-generated missiles. The tornado parameters are based on a 100,000-year period of recurrence.

The design parameters applicable to the design tornado are as follows:

Design wind speed:	302 km/hr	(188 mi/hr)
Radius of damaging winds:	130 m	(425 ft)
Atmospheric pressure change (APC):	-390 kg/m^2	(-80 lb/ft^2)
Rate of APC:	-146 kg/m^2/s	(-30 lb/ft^2/s)

The procedures used for transforming the impactive missile loadings into effective loads are discussed in Section 3.3.2.2.3, Projectile Protection.

3.3.2.2.2.2 Hurricane

The NEF site is approximately 805 km (500 mi) inland from the nearest coastline. Hurricane wind is not a governing condition in comparison to normal wind and tornado wind.

3.3.2.2.3 Projectile Protection

Projectile protection is provided for all equipment, systems and components in the safety significant areas such that internally generated or externally generated missiles will not cause the release of radioactive materials that exceeds the 10 CFR 70.61 performance requirements or prevent the safe and orderly shutdown of the facility.

3.3.2.2.3.1 Internal Projectiles

Internally generated projectiles are not a concern in the Separations Building Modules (SBMs). The types of equipment that are potential sources of projectiles are blowers, fans, pumps, compressors, high pressure gas cylinders and the centrifuges. The centrifuges have been tested to mechanical failure. These tests have demonstrated that the centrifuge casing will contain any internal projectiles generated as a result of a centrifuge failure. Likewise, in the SBMs and other safety significant areas of the facility, the components of the other pieces of rotating equipment located in these areas that could become missiles do not have sufficient energy to break through their respective housings or casings. Also, there are no high energy piping systems in these areas that could be the source of jet impingements or pipe whip. High pressure gas cylinders will be handled and stored on site to preclude the generation of internal missiles.

3.3.2.2.3.2 External Projectiles

The only external projectiles that have been identified as a design consideration are tornado-generated missiles. The barriers and buildings protecting equipment and components in the safety significant areas, with the exception of the SBMs and the CRDB shell (non-Bunkered Area), are designed to withstand and absorb tornado generated missile impact loads without causing any damage to the protected equipment and components.

Aircraft crashes are not credible events for the NEF site. Additional information concerning aircraft crashes is found in Section 3.2.

A. Tornado-Generated Missiles

The tornado-generated missiles are associated with the tornado event described in Section 3.3.2.2.2.1, Tornado. The types of missiles selected and the related design parameters were determined as part of the tornado study for the NEF site. These missiles are associated with the design basis tornado (DBT), which has an annual probability of occurrence of 1.0E-5. The design parameters include:

Missile: 2 in. x 4 in. timber plank, 6.80 kg (15 lb)

Horizontal speed	137 km/hr	(85 mi/hr)
Maximum height above ground.	60 m	(200 ft)
Vertical speed	88 km/hr	(57 mi/hr)

Missile: 76.2 mm (3 in) diameter, steel pipe, 34 kg (75 lb)

Horizontal speed	80 km/hr	(50 mi/hr)
Maximum height above ground	9.1 m	(30 ft)
Vertical speed	48 km/hr	(30 mi/hr)

Missile: Automobile, 1361 kg (3000 lb)

Horizontal speed	32 km/hr	(20 mi/hr)

The missile impact generates two types of effects on the barriers and buildings. First are the local effects, and second are the overall responses of the barrier and portions thereof to missile impact. The procedures employed in the design of the barriers for those effects are described below.

B. Local Effects of Tornado-Generated Missiles on Building Structures

The missiles are categorized as either hard or soft relative to the target. A missile is considered hard if the average crushing or buckling limit stress of the missile is greater than the average contact stress required to cause local crushing and penetration of the target. Missiles not meeting the above condition are considered soft missiles. The timber missile is considered soft and the steel pipe missile is considered hard. For reinforced concrete targets, the formulas used to establish the missile depth of penetration (x) and scabbing thickness (ts) are based on the Modified National Defense Research Committee Formula (NDRC) (ASCE58) and the Army Corps of Engineers Formula (ACE) (ASCE58) respectively.

The modified NDRC formulas for penetration is given by:

$$x = \sqrt{4KNWd\left(\frac{V}{1{,}000d}\right)^{1.80}} \quad \text{, for } \frac{x}{d} \le 2.0 \qquad \text{(Eq. 3.3-5)}$$

$$x = \left\{\left[KNW\left(\frac{V}{1000d}\right)^{1.80}\right] + d\right\} \quad \text{, for } \frac{x}{d} > 2.0 \qquad \text{(Eq. 3.3-6)}$$

The ACE Formula for scabbing is given by:

$$\frac{t_s}{d} = 2.12 + 1.36\frac{x}{d}\text{, for } 0.65 \le \frac{x}{d} \le 11.75 \qquad \text{(Eq. 3.3-7)}$$

The variables used in the NDRC and ACE formulas are defined below:

N = missile shape factor which has a value of 0.72 for flat-nosed missiles

d = $\left(\frac{4A_c}{\pi}\right)^{\frac{1}{2}}$ = effective missile diameter, in.

W = missile weight, lbs.

K = $\frac{180}{\sqrt{f'c}}$

f'_c = ultimate compressive strength of concrete, psi

A_c = missile contact area, sq in.

x = missile depth of penetration, in.

t_s = scabbing threshold thickness, in.

V = striking velocity of missile, fps

Per Section C.7.2.1 of ACI 349, the concrete thickness required to resist hard missiles shall be at least 1.2 times the scabbing thickness, t_s. References indicate that the soft missiles will cause no local penetration with the exception of possible punching shear failure. Punching shear is calculated and checked against the requirements of ACI 349, Section C.7.2.3.

For steel targets, the formula used to establish the perforation thickness is the Ballistic Research Laboratory (BRL) Formula (ASCE 58).

The BRL Formula to determine the target thickness is given by:

$$\left(\frac{e}{d}\right)^{1.5} = \frac{DV^2}{1{,}120{,}000K_s^2} \qquad \text{(Eq. 3.3-8)}$$

Where:

K_s = Steel penetrability constant depending upon the grade of the steel target, usually taken as 1.0.

$D = \frac{W}{d^3}$ = missile caliber density, lbs/in^3

$d = \left(\frac{4A_c}{\pi}\right)^{\frac{1}{2}}$ = effective missile diameter, in.

A_c = missile contact area, sq in.

e = perforation thickness, in.

V = striking velocity of missile, fps

W = missile weight, lbs

References indicate that the recommended steel target thickness is 1.25 times the perforation thickness (ASCE, 50, p. 346).

C. Overall Structural Response

In addition to local impact effects, the barriers and building structures are designed to resist the overall effects of missile impact. The response of the structure to missile impact depends largely on the location of impact, the dynamic properties of the structure (target), and the kinetic energy of the missile.

3.3.2.2.4 Water Level

Based on setting the grade level of the facility above the maximum foreseeable flood level, the only potential flooding of the facility results from local intense rainfall. Protection against flooding is provided by establishing the facility floor level at 0.15 m (0.5 ft) above the finished grade elevation adjacent to facility buildings with a finished site topography that will direct rain water away from the facility buildings. In addition, in order to prevent general site flooding from the contributory areas above the site, an intercept trench will be constructed uphill of the buildings. Based on these design features, the probability of the water level reaching the building finished floor is negligible. Section 3.2, provides in detail the effects of flood from local intense precipitation. Additionally, for roof access doors, the door sill elevation shall be at least 6" above the top of the built up roofing.

3.3.2.2.5 Seismic Loadings

3.3.2.2.5.1 Building Code Earthquake

All buildings and structures, including such items as equipment supports, are designed to withstand the earthquake loads defined in Section 1615 of the International Building Code. Every structure is designed to resist the total lateral seismic forces acting nonconcurrently in the direction of each of the main axes of the structure.

Although much of the facility is of a critical nature and the additional safety factor for developing seismic forces on these structures is provided by using the occurrence probability of 10^{-4}, all buildings will be taken as Seismic Use Group II structures per International Building Code Section 1616.2.

Mapped spectral accelerations for short term (i.e. S_s for 0.2 second period) and long term (S1 for 1.0 second period) have been obtained from Figures 1615(1) and 1615(2) of the International Building Code. Associated Site Coefficients have been obtained from International Building Code Tables 1615.1.2(1) and 1615.1.2(2).

The seismic design base shear in a given direction is determined by the following correlation based on Equation 16-56 of the International Building Code:

$$V = \frac{1.2 S_{DS}}{R} \cdot W \qquad \text{(Eq.3.3 – 9)}$$

$$S_{DS} = \frac{2}{3} \cdot S_{MS} \qquad \text{(Eq.3.3 – 10)}$$

$$S_{MS} = F_a \cdot S_s \qquad \text{(Eq.3.3 – 11)}$$

Where:

V = Lateral force or base shear

S_{DS} = Design elastic response acceleration for short period, equal to (2/3) S_{MS} International Building Code Equation 16-40

S_{MS} = Maximum considered earthquake spectral response accelerations for short period per International Building Code Section 1615.1.2

F_a = Short-period site coefficient per International Building Code Table 1615.1.2(1)

W = Effective seismic weight of structure

R = Response modification factor per International Building Code Table 1617.6.2

3.3.2.2.5.2 Design Basis Earthquake

The Design Basis Earthquake (DBE) for the NEF site has a peak horizontal acceleration of 0.161g and peak vertical acceleration of 0.1074g based on ASCE 43-05. The design spectra associated with these values are based on 10% damping in accordance with Limit State C of ASCE 43-05. Soil amplification factors are based on Soil Class C. This assumption will be verified during final design. Refer to Section 3.2, for a detailed discussion of the geology and seismicity of the region used in determining the DBE.

3.3.2.2.6 Precipitation Loadings

3.3.2.2.6.1 Snow Loadings

Extreme snow loadings on roofs of safety significant structures are based on a design basis ground snow load of 32 lb/ft^2. The design basis ground snow load for safety significant structures is enveloped by the general 40 psf roof live load with the exception of drift areas. Drift areas (where load can exceed 40 psf) are evaluated when required for each structure. Quality Level 3 structure will as a minimum, meet the IBC requirements for design basis ground snow loading.

3.3.2.2.6.2 Rainfall Loadings

For all buildings, rainwater will be carried away from the roof surfaces using rain gutters and intermittent down spouts along the building perimeter. The roofs are provided with adequate slope to prevent localized ponding. The rain loading for Safety Significant Structures are enveloped by the general 40 psf roof live load. Quality Level 3 structures will as a minimum, meet the IBC requirements for rain loading.

3.3.2.2.7 Process and Equipment Derived Loadings

The various buildings and structures are designed to support the equipment, piping, duct and tray associated with them. Dead loads, fluid loads, impact loads, seismic loads and other

dynamic loads are accounted for in the design. In addition to the buildings, individual supports are designed to withstand these same types of loads.

Loads from piping, HVAC, and cable tray, conduit and unknown equipment shall be estimated based on the specific plant layout to the greatest extent possible, and also based on expected usage of the area. For design development purposes, these loads shall not be less than the following values in general areas (uniformly distributed over entire floor or wall):

- 10 psf for roofs and floor slabs
- 5psf for walls (loads perpendicular to wall)

For design development purposes, loads for design of the Process Services corridors in the SBM, and UF_6 Area utility corridors shall not be less than the following values (uniformly distributed over entire floor or wall):

- 20 psf for floor slabs
- 10 psf for walls (loads perpendicular to wall)

Individual supports for QA Level 3 commodities located in the vicinity of QA Level 1 equipment, such that failure of the support could result in an interaction with seismic designed QA Level 1 equipment, shall be designed to preclude unacceptable interaction.

Analyses that include estimated loads based on the above are verified as bounding upon completion of the final design prior to any IROFS performing their required function.

3.3.2.2.8 Combined Loadings for Structures

For all concrete structures, the load combinations using strength design are from IBC and ASCE 7. For all steel structures, the load combinations using allowable stress design are from IBC and ASCE 7. Safety significant structures comply with the additional load combinations listed in 3.3.2.2.8.3.A for concrete structures and 3.3.2.2.8.3.B for steel structures. Load combinations for components for all buildings are based on ASCE 7. Use of additional or alternate load combinations is acceptable so long as the equivalent load types are considered, and the alternate load combinations are deemed to be equivalent or more conservative than the load combinations listed in 3.3.2.2.8.3.Loads are considered to act in various load combinations as listed in this section. Results are checked for whatever combination produces the most unfavorable effects for the buildings, foundations or other structural components being considered.

All major loads encountered and/or postulated in a safety significant structure or component are listed in three categories described below.

3.3.2.2.8.1 Normal Loads

Normal loads are those loads encountered during normal facility operation. They include the following:

A. Dead (D)

Dead loads include gravitational load of structures, permanent equipment, piping, static liquid, long term stored materials, permanent partitions and any other permanent static load.

B. Live (L or LR)

Live loads include the weight of moveable objects such as personnel and equipment, temporarily stored materials, tools, moveable partitions, transporters, hoists and cranes. Design live loads, including impact loads, used are in accordance with Section 4.0 and Table 4-1 of ASCE 7.

C. Self-Straining (T)

Self-straining forces and effects arise from the restraint of a structural member from expansion or contraction due to temperature change, shrinkage, creep or differential settlement.

D. Pressure (F)

Lateral and vertical pressure of liquid or gases due to their containment within a structure.

E. Lateral Earth Pressure (H)

The lateral earth pressure acting on foundations, buried walls or retaining walls.

F. Environmental Loads

Environmental loads include the following:

1. Snow (S)

   Snow loads are discussed in Section 3.3.2.2.6, Precipitation Loadings.

2. Rainfall (R)

   Normal rainfall loads are discussed in Section 3.3.2.2.6.

3. Wind (W)

   Wind loads are discussed in Section 3.3.2.2.1, Wind Loadings.

4. Earthquake (Eo)

   Building code earthquake loads are discussed in Section 3.3.2.2.5, Seismic Loadings. The Operating Basis Earthquake, also denoted as Eo in ACI 349 is not applicable to this facility since no Operating Basis Earthquake has been defined for the project. However, all structures are designed for the normal Building Code earthquake and all safety significant buildings are designed to the Safe Shutdown Earthquake.

G. Process and Equipment Reactions (Ro)

Process and equipment derived loads are discussed in Section 3.3.2.2.7, Process and Equipment Derived Loadings.

H. Postulated Pipe Break Loads

As discussed in Section 3.3.2.2.3.1, pipe break loads are not postulated for this facility.

3.3.2.2.8.2 Extreme Environmental Loads

Extreme environmental loads are those loads that are credible but highly improbable. They include the following:

A. Design Basis Tornado (Wt)

The Design Basis Tornado loads are made up of 3 load components acting in various combinations. The load components are:

1. Tornado wind velocity pressure (Ww)

2. Tornado induced differential pressure (Wp)

3. Tornado generated missile load (Wm)

Items 1. and 2. are discussed in Section 3.3.2.2.2. Item 3. is discussed in Section 3.3.2.2.3.

The three load components can act in the following combinations as described in USNRC NUREG-0800.

a. $W_t = W_w$

b. $W_t = W_p$

c. $W_t = W_m$

d. $W_t = W_w + W_m$

e. $W_t = W_w + 0.5\ W_p$

f. $W_t = W_w + 0.5\ W_p + W_m$

B. Safe Shutdown Earthquake (Es)

Loads from the Safe Shutdown Earthquake (i.e., DBE) are discussed in Section 3.3.2.2.5.

C. Design Basis Flood (DBFL)

Loads from the Design Basis Flood are discussed in Section 3.3.2.2.4.

D. Truck and Gas Pipeline Hazards

Explosion hazards from trucks (e.g., propane trucks) on highways near the NEF site are described in Section 3.2.1.2.1. Explosion hazards from gas pipelines near the NEF site are described in Section 3.2.2.4, Industrial Areas. During detailed design of specific buildings and areas, pressure loads due to postulated truck and pipeline explosions will be considered. The pressure loads will be developed in accordance with the underlying assumptions used in the explosion hazard assessments described in Sections 3.2.1.2.1 and 3.2.2.4. These buildings and areas include: Separations Building Modules (UF_6 Handling Area, Process Services Corridor and Cascade Halls), and Cylinder Receipt and Dispatch Building. Section 3.3.1, Buildings and Major Components, describes these buildings.

3.3.2.2.8.3 Combined Load Applications

A. In addition to complying with the load combinations required by the building code, the following additional load combinations are applicable for safety significant concrete structures combining factored loads using Strength Design. Load combinations related to pipe breaks and the operating basis earthquake have been eliminated as discussed in Section 3.3.2.2.8.1.

1. $U = 1.4D + 1.4F + 1.7(L_R \text{ or } S \text{ or } R) + 1.7H + 1.7R_o$

2. $U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.7Ro$

3. $U = 1.05D + 1.05F + 1.3L + 1.3H + 1.05T + 1.3Ro$

4. $U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3W + 1.05T + 1.3Ro$

For extreme environmental conditions the following load combinations are satisfied:

5. $U = D + F + L + H + T + R_o + E_s$

6. $U = D + F + L + H + T + R_o + W_t$

7. U - Used for concrete structures, U is the required strength to resist factored loads or related internal moments, shears and forces, based on methods described in ACI 349.

B. In addition to complying with the load combinations required by the building code, the following additional load combinations are applicable for safety significant steel structures combining nominal loads using Allowable Stress Design.

1. $S = D$

2. $S = D + L + F + H + T + (L_r \text{ or } S \text{ or } R)$
3. $S = D + (W \text{ or } 0.7E_o) + L + (L_r \text{ or } S \text{ or } R)$
4. $S = 0.6D + W + H$
5. $S = 0.6D + 0.7E_o + H$

For extreme environmental conditions the following load combinations are satisfied:

6. $S = 0.625(D + L + T + Ro + Es)$
7. $S = 0.625(D + L + T + Ro + Wt)$
8. S - Used for structural steel, S is the required section strength based on the elastic design methods and the allowable stresses defined in the AISC Manual of Steel Construction-Allowable Stress Design and AISC N690.

Load Combinations and Requirements for Foundations

All foundations are checked against sliding and overturning due to earthquake, wind, Design Basis Earthquake and Design Basis Tornado in accordance with the following:

Minimum Factors of Safety

Load Combination	Overturning	Sliding
$D + H + E_o$	1.5	1.5
$D + H + W$	1.5	1.5
$D + H + E_s$	1.1	1.1
$D + H + W_t$	1.1	1.1

The allowable stresses cannot exceed 0.7 times the ultimate tensile strength ($0.7F_u$) in axial tension nor 0.7 times the ultimate tensile strength times the ratio of plastic section modulus to elastic section modulus ($0.7F_u$ Z/S).

3.3.2.3 Foundations

Foundations are shallow concrete spread strip footings. Allowable bearing pressures can be found in Table 5.8-2 and Figures 5.8-1 and 5.8-2 of the Geotechnical Report (NTS Report 114489-G-01, Rev. 00), and these values are based on the assumptions in Section 5.8 of the Geotechnical Report.

3.3.2.4 UF_6 Process Systems Piping and Components

For all SBMs, UF_6 process system piping and component that are required to maintain pressure boundary integrity after a seismic event will be designed to withstand the Design Basis Earthquake (DBE). The DBE meets the requirements for Seismic Design Category 5 (SDC-5), as required by ASCE 43-05. The seismic uniform hazard response spectra associated with the DBE is described in Section 3.2.6.4.3 and 3.2.6.5 of the Integrated Safety Analysis (ISA) Summary and will be finalized in accordance with ASCE 43-05 as part of the detailed design.

Equipment mounted on grade level, floating floor slabs in the SBM will be designed for the DBE ground motion. Equipment and systems that are mounted at higher elevations of the SBM building where amplification will occur must be evaluated for the loads associated with the amplified seismic ground motions. Dynamic amplification of the building is accounted for using In-structure Spectra (ISRS). The ISRS of the SBM is determined using the methods specified in ASCE 43-05 and ASCE 7-02.

Depending on the actual seismic pressure boundary, potential design and analysis requirements for qualification of the UF_6 process systems piping and components are summarized as follows:

- The UF_6 piping shall meet the requirements of ASME B31.3, Process Piping, with the additional requirements of AME B31.3, Chapter VII, "Piping for Category M Fluid Service."

- ASME B31.3 Paragraph 301.52 required that the piping be designed for earthquake-induced horizontal and vertical loads. The allowable stresses for the DBE are given in ASME B31.3 Paragraph 302.3.6, "Limits of Calculated Stress due to Occasional Loads," which permits an increase over the basic allowable stresses of 1.33 for occasional loads.

- Components and vessels in the UF_6 piping systems are also required to maintain pressure boundary integrity after a DBE event. ASME B31.3, Chapter IV, provides the requirement for design of piping components and demonstration of the seismic adequacy of components used in UF_6 piping systems. Acceptable methods include, but are not limited to:

    - Extensive, successful service experience under comparable conditions.
    - Detailed Stress analysis with results evaluated as described in ASME Boiler and Pressure Vessel Code, Section VII, Division 2, appendix 4, Article 4-1.
    - Pressure vessels may also be designed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels, and analyzed for all loading conditions.

- The UF_6 cylinders that meet the requirements of DOT 7A, Type A are considered to be acceptable for seismic loading.

- Pipe joints shall meet the requirements of ASME B31.3, Chapter II, Part 4, "Fluid Service Requirements for Piping Joints." Piping flanges shall meet the requirements of ASME B31.3 Part 3. This approach is considered sufficient to show that the flanged connection is leak-tight before and after a DBE. However, it does not necessarily ensure the connection is leak-tight during the DBE. Potential loss of integrity during the DBE is considered acceptable because loss of joint integrity during the DBE will be temporary and because the UF_6 systems operate under a vacuum; any temporary leakage at a flanged connection will be in-leakage.

- The seismic design criteria for all structural elements of systems and equipment that must maintain pressure boundary integrity after a DBE including component supports, equipment anchorages and steel support structures are in accordance with ASCE 43-05. The allowable stresses for the seismic loading combinations shall meet the requirement for extreme environmental loads.

- The centrifuges are supported by Floor Mounted Elements (flomels). The seismic qualification of the flomels will be performed by either analysis or testing.

- Seismic qualification of the centrifuges requires that the centrifuge maintain pressure tight integrity and remain in the upright position during the seismic event.

3.3.3 References

Edition of Codes, Standards, NRC Documents, etc that are not listed below are given in Table 3.0-1.

CFR, 2003. Title 10, Code of Federal Regulations, Section 70.64, Requirements for new facilities or new processes at existing facilities, 2003.

NRC, 1982. Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, Regulatory Guide 1.145, Revision 1, U.S. Nuclear Regulatory Commission, 1982.

NTS Report No. 114489-G-01, Revision 00. Geotechnical Report for the National Enrichment Facility in Lea County, New Mexico, Prepared by Nuclear Technology Solutions, LLC, Cherry Hill, NJ, November 10, 2005.

PCI, 1999. Precast Concrete Institute Design Handbook: Precast and Prestressed Concrete, Fifth Edition, MNL-120-99, Precast Concrete Institute, 1999.

UBC, 1997. Uniform Building Code, International Conference of Building Officials, ICBO, 1997.

3.3.4 Section 3.3 Tables

Table 3.3-1 Distances To Site Boundary and To Restricted Area Boundary and Wind Frequencies

Compass Direction from Facility	Distance from Facility to Site Boundary (meters)	(feet)	Distance from Facility Building Complex to Restricted Area Boundary (meters)	(feet)	Distance from UBC Storage Pad to Restricted Area Boundary (meters)	(feet)	Frequency of Wind (%)
S	417	1368	26.4	87	81.6	268	5.66
SSW	417	1368	26.4	87	-	-	3.98
SW	422	1384	28.8	94	-	-	4.91
WSW	503	1650	148.8	488	-	-	4.87
W	769	2522	168.0	551	33.6	110	6.29
WNW	1071	3513	168.0	551	-	-	5.52
NW	1072	3516	182.4	598	-	-	7.52
NNW	995	3264	93.6	307	-	-	10.80
N	995	3264	93.6	307	28.8	94	20.40
NNE	754	2473	93.6	307	-	-	7.35
NE	581	1906	100.8	331	-	-	5.46
ENE	540	1771	72.0	236	-	-	4.68
E	540	1771	57.6	189	33.6	110	4.45
ESE	540	1771	33.6	110	-	-	2.42
SE	487	1597	28.8	94	-	-	2.69
SSE	417	1368	26.4	87	-	-	3.04

3.3.5 Section 3.3 Figures

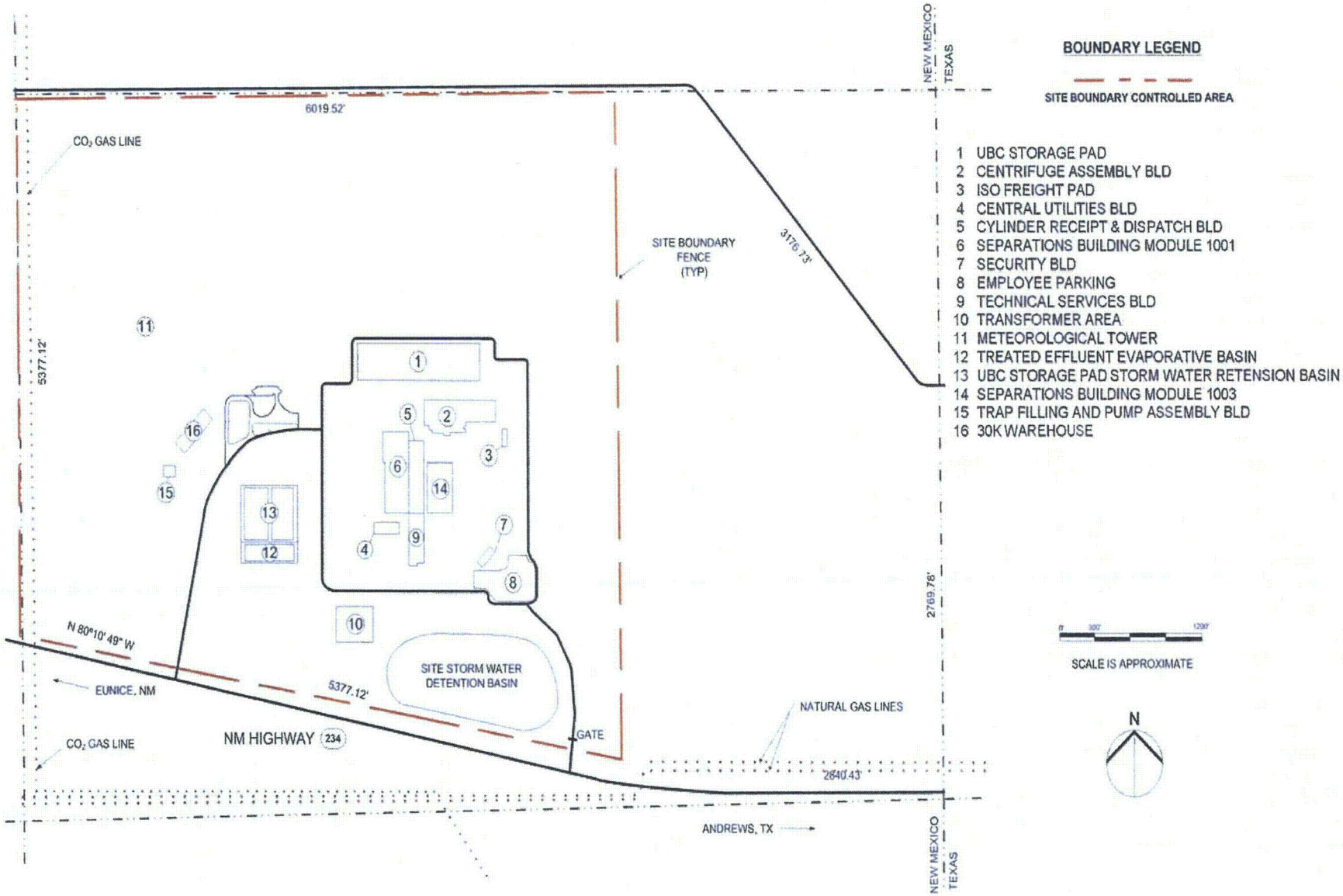


Figure 3.3-1 Facility Buildings and Areas

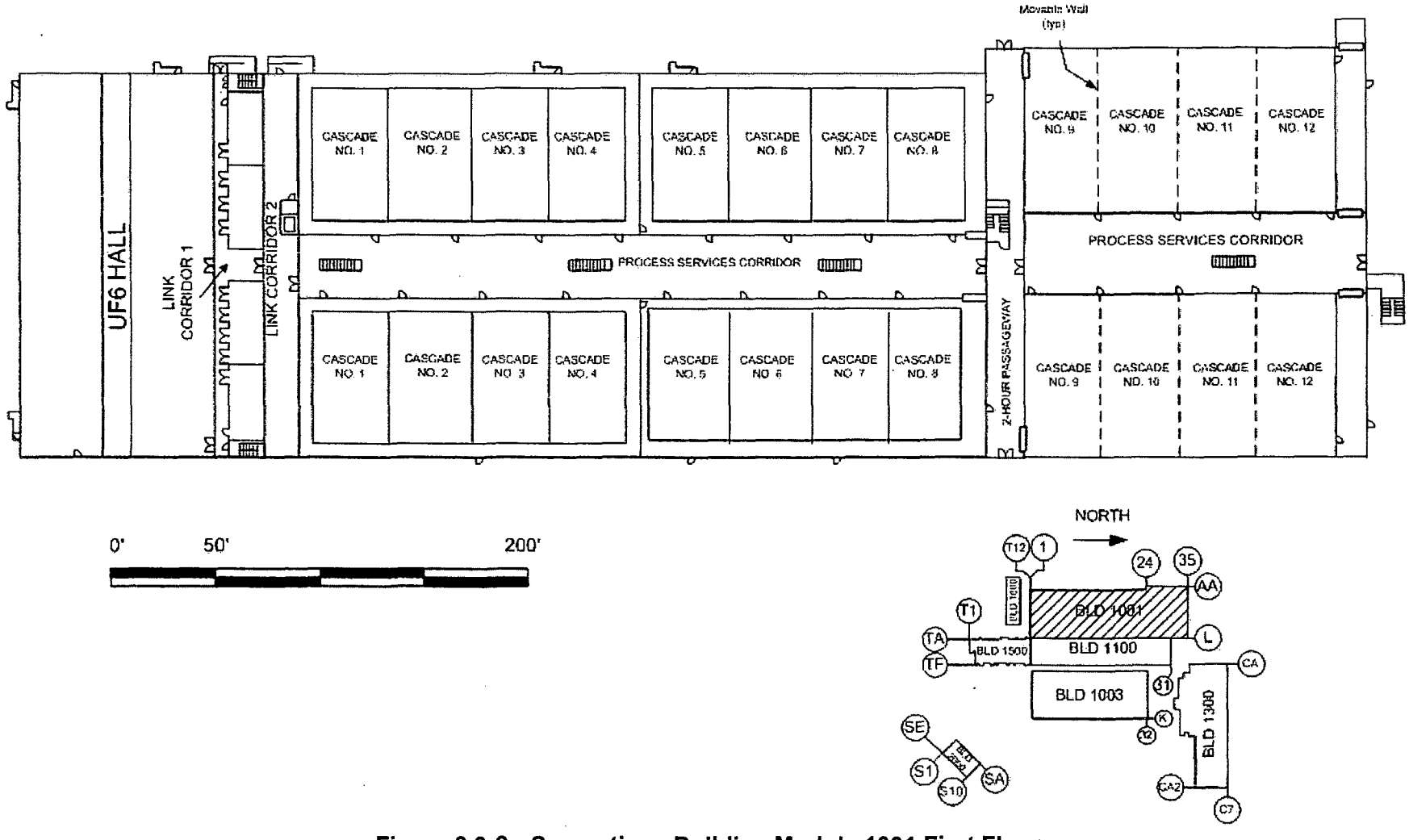
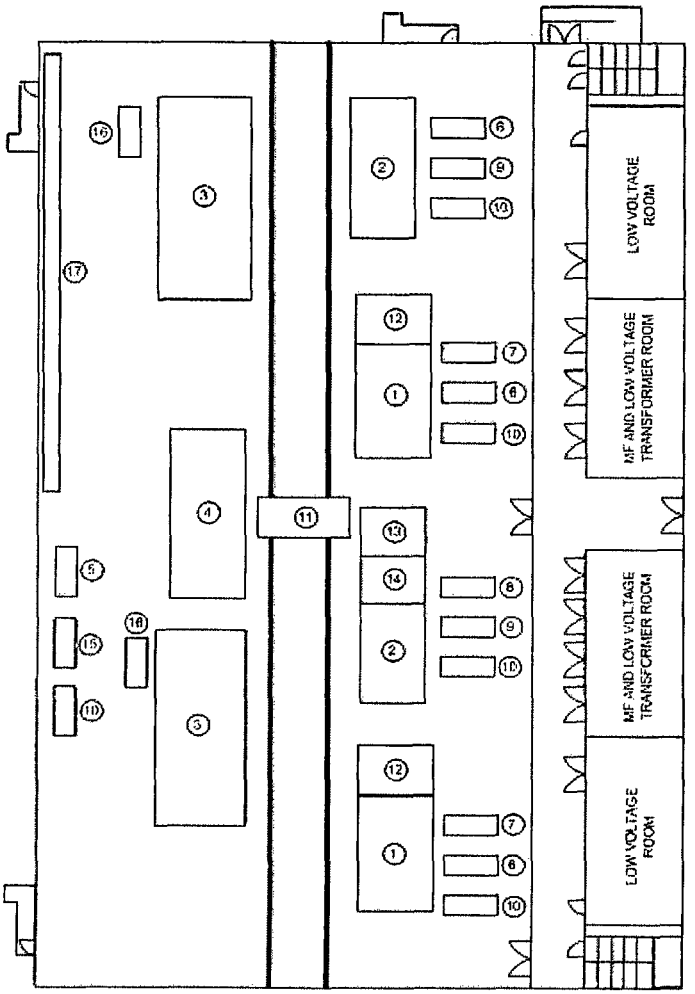
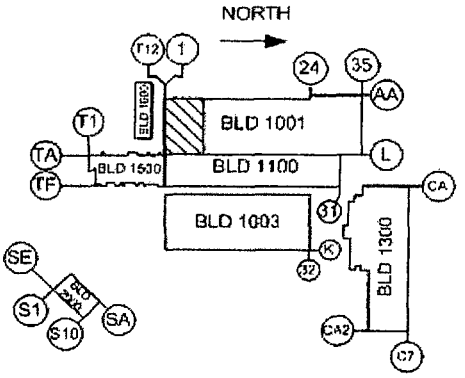


Figure 3.3-2 Separations Building Module 1001 First Floor





1 SOLID FEED STATIONS
2 PRODUCT STATIONS
3 TAILS STATIONS
4 AUTOCLAVES
5 DONOR RECEIVER VACUUM PUMP TRAP SET
6 FEED PURIFICATION COLD TRAP
7 FEED PURIFICATION VACUUM PUMP TRAP SET
8 PRODUCT VACUUM PUMP TRAP SET
9 PRODUCT VENT COLD TRAP
10 COLD TRAP HEATER/CHILLER SET
11 RAIL TRANSPORTER
12 FEED PURIFICATION STATIONS
13 DONOR STATIONS
14 RECEIVER STATIONS
15 DONOR RECEIVER COLD TRAP
16 TAILS VACUUM PUMP TRAP SET
17 PUMPED EXTRACT GEVS

Figure 3.3-3 Separations Building Module 1001 UF_6 Handling Area Equipment Locations

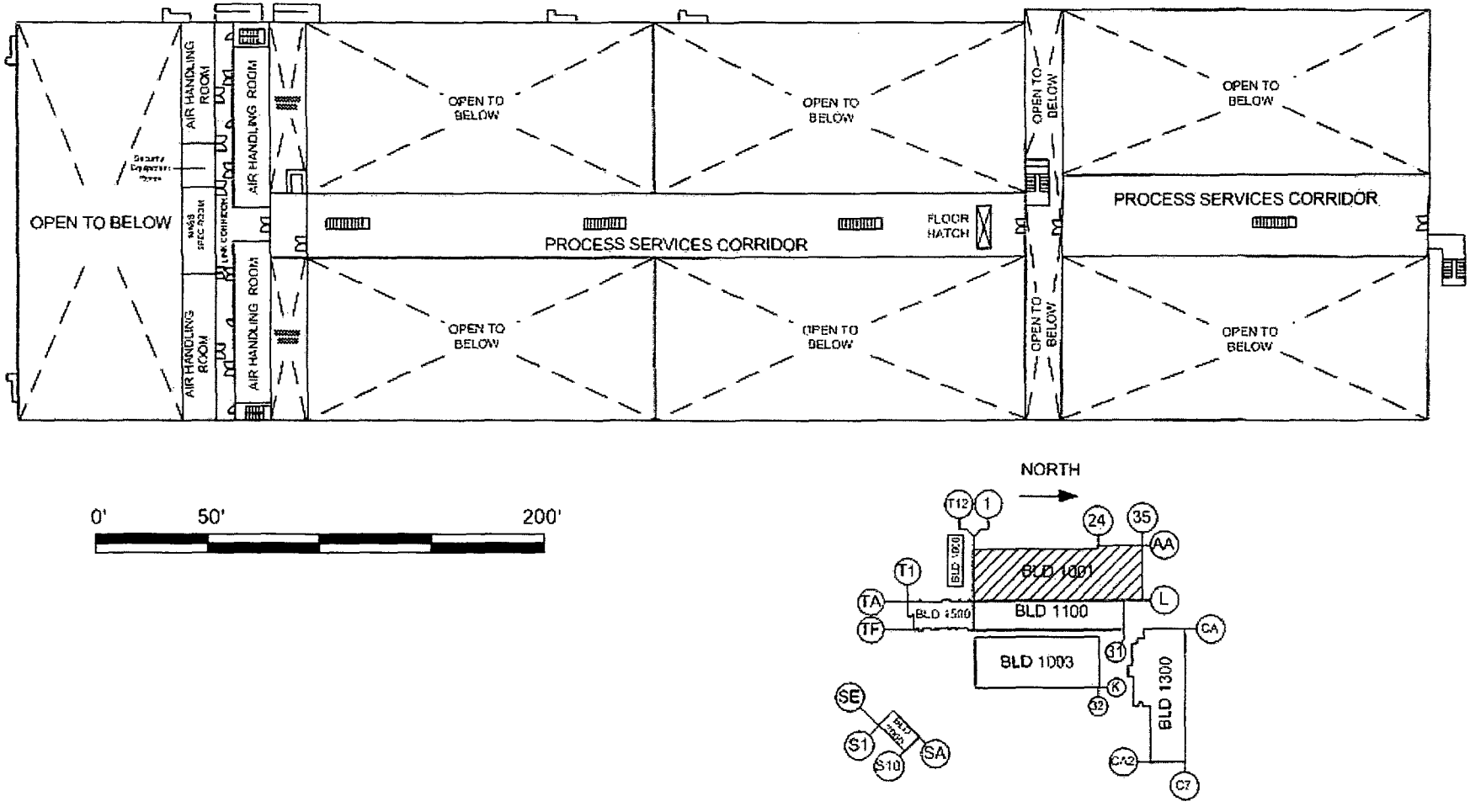


Figure 3.3-4 Separations Building Module 1001 Second Floor

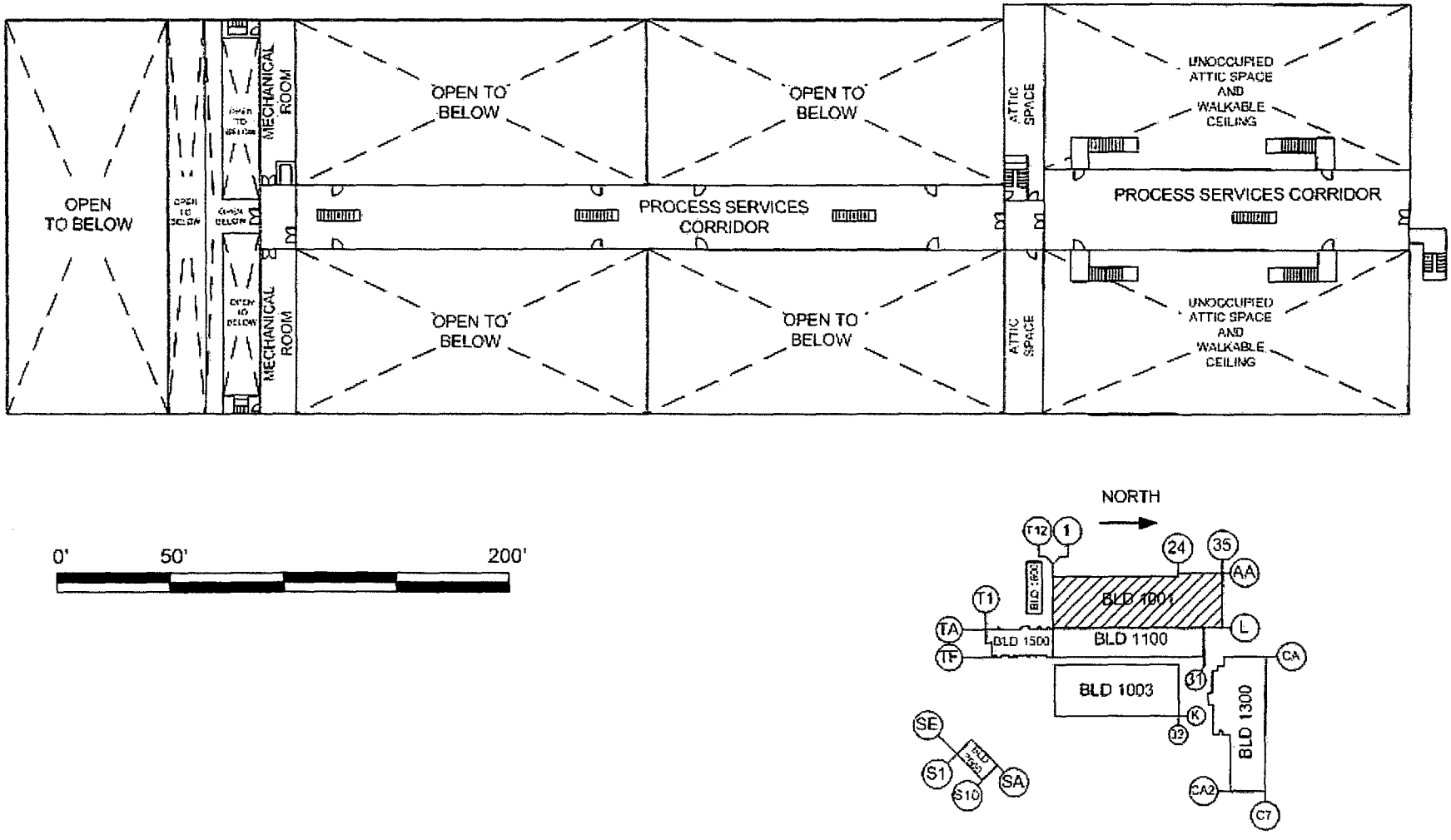


Figure 3.3-5 Separations Building Module 1001 Third Floor

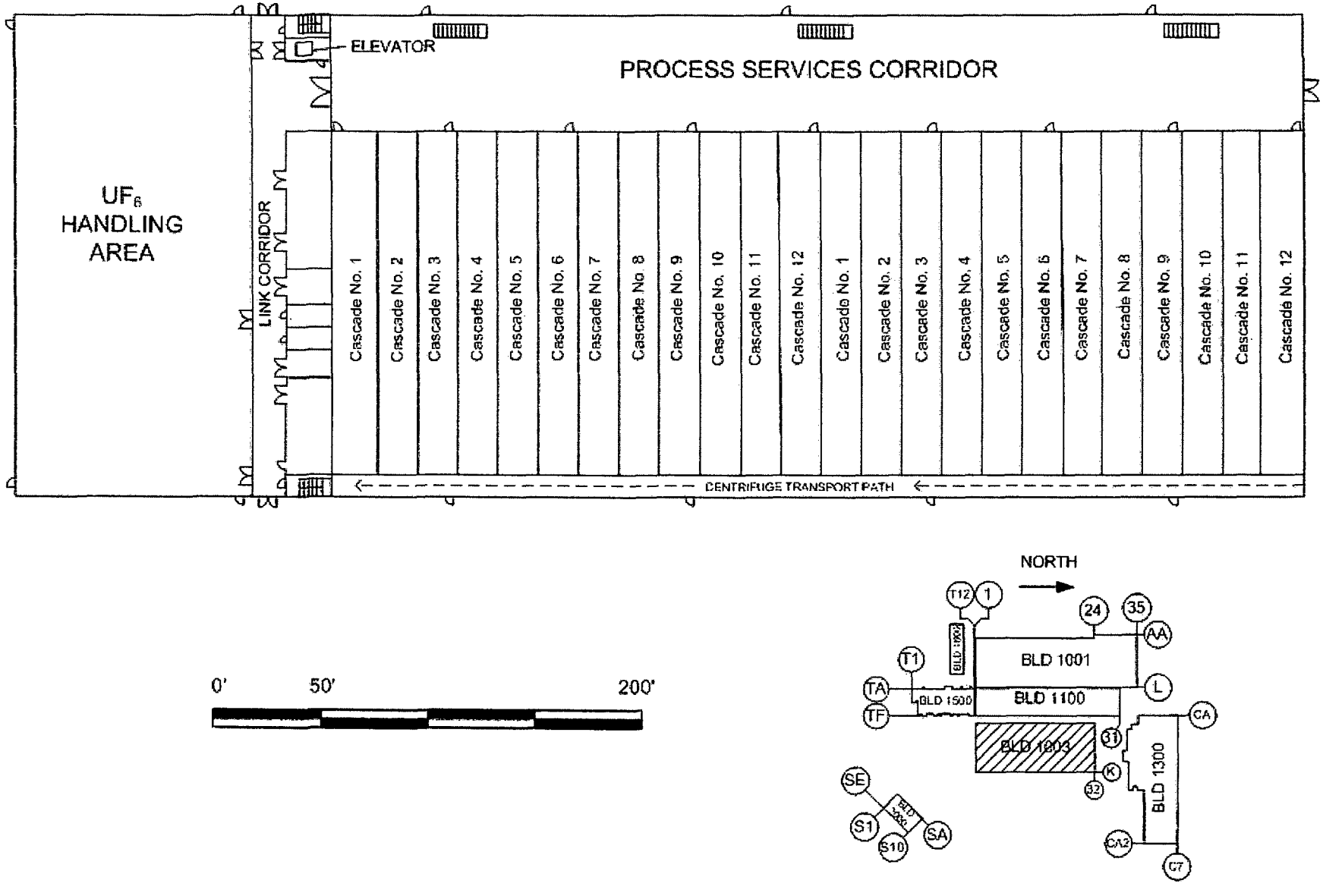
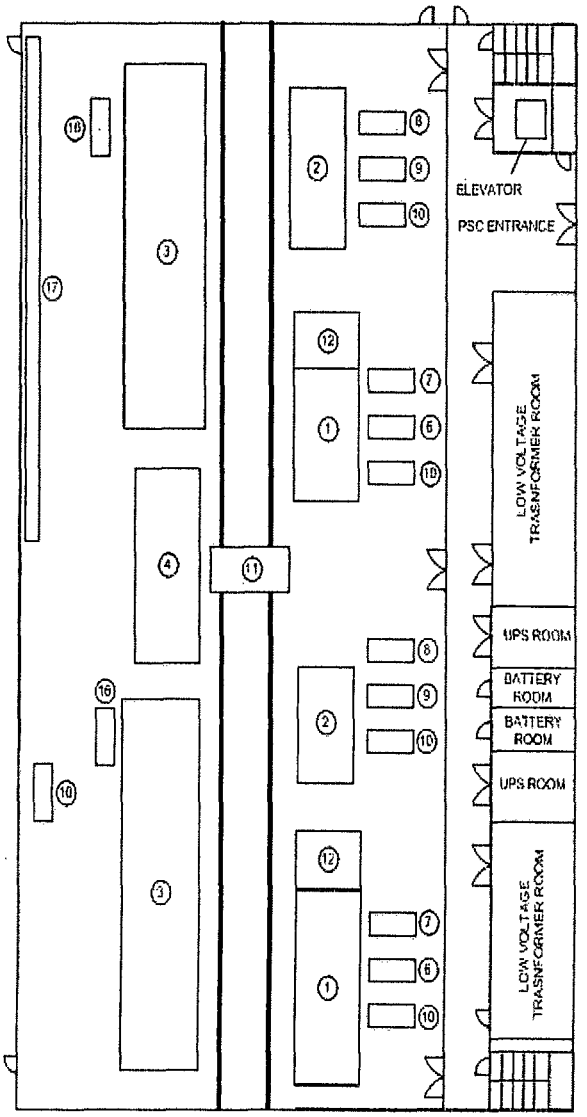


Figure 3.3-6 Separations Building Module 1003 First Floor



1 SOLID FEED STATIONS
2 PRODUCT STATIONS
3 TAILS STATIONS
4 AUTOCLAVES
6 FEED PURIFICATION COLD TRAP
7 FEED PURIFICATION VACUUM PUMP TRAP SET
8 PRODUCT VACUUM PUMP TRAP SET
9 PRODUCT VENT COLD TRAP
10 COLD TRAP HEATER/CHILLER SET
11 RAIL TRANSPORTER
12 FEED PURIFICATION STATIONS
16 TAILS VACUUM PUMP TRAP SET
17 PUMPED EXTRACT GEVS

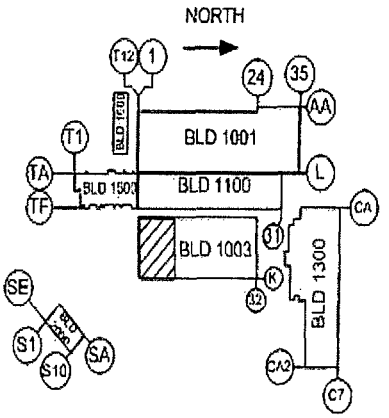


Figure 3.3-7 Separations Building Module 1003 UF_6 Handling Area Equipment Locations

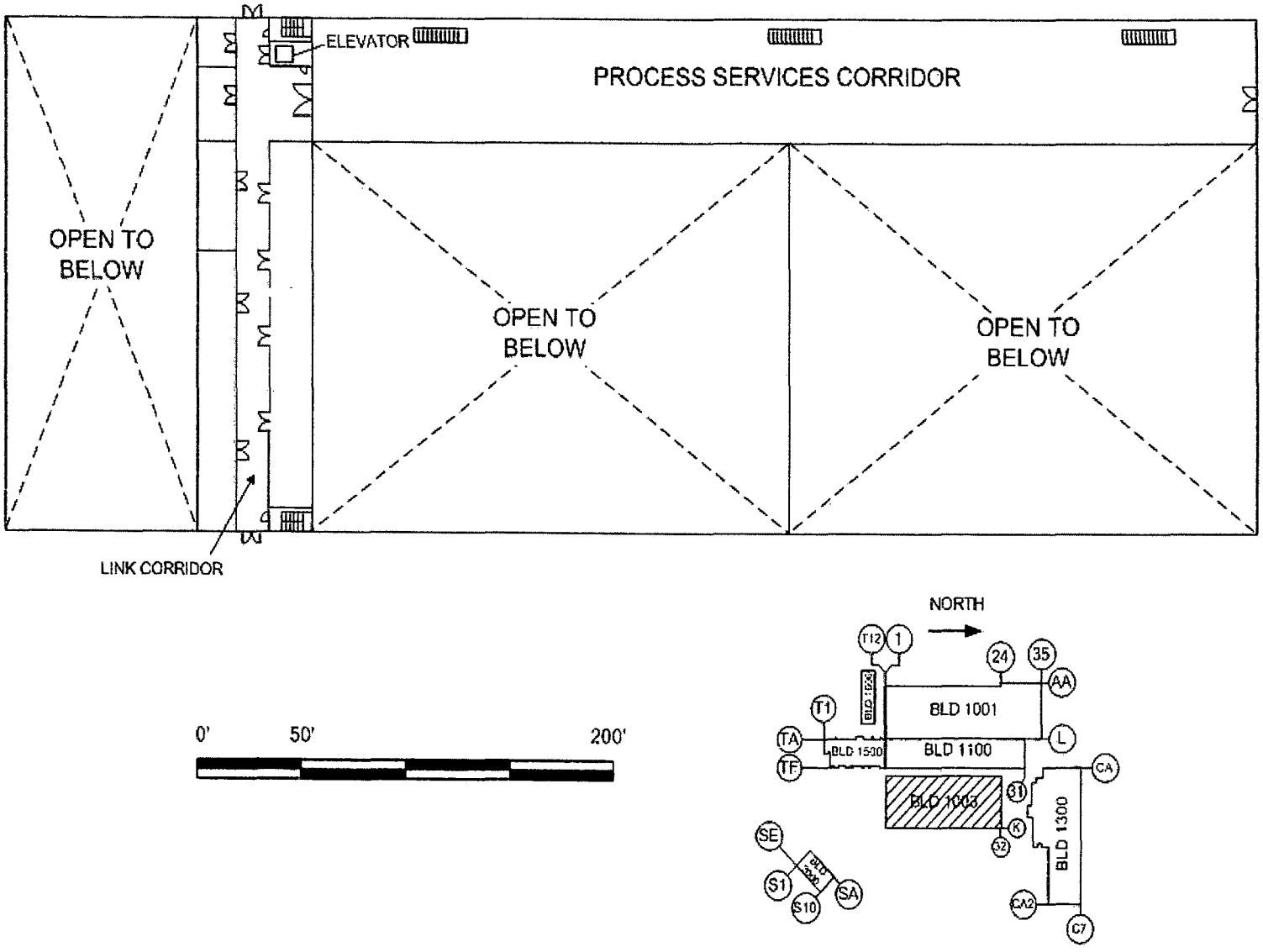


Figure 3.3-8 Separations Building Module 1003 Second Floor

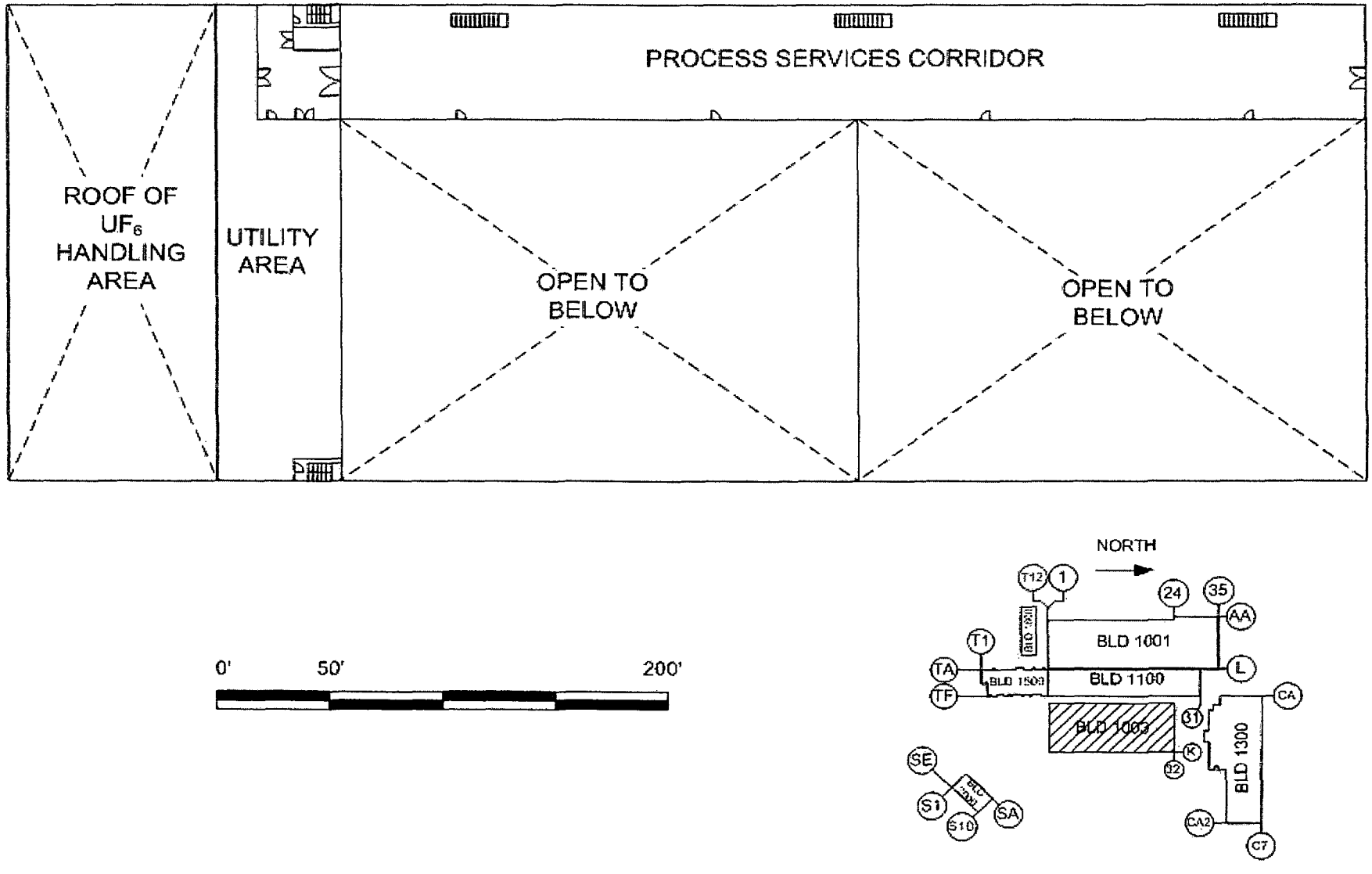


Figure 3.3-9 Separations Building Module 1003 Third Floor

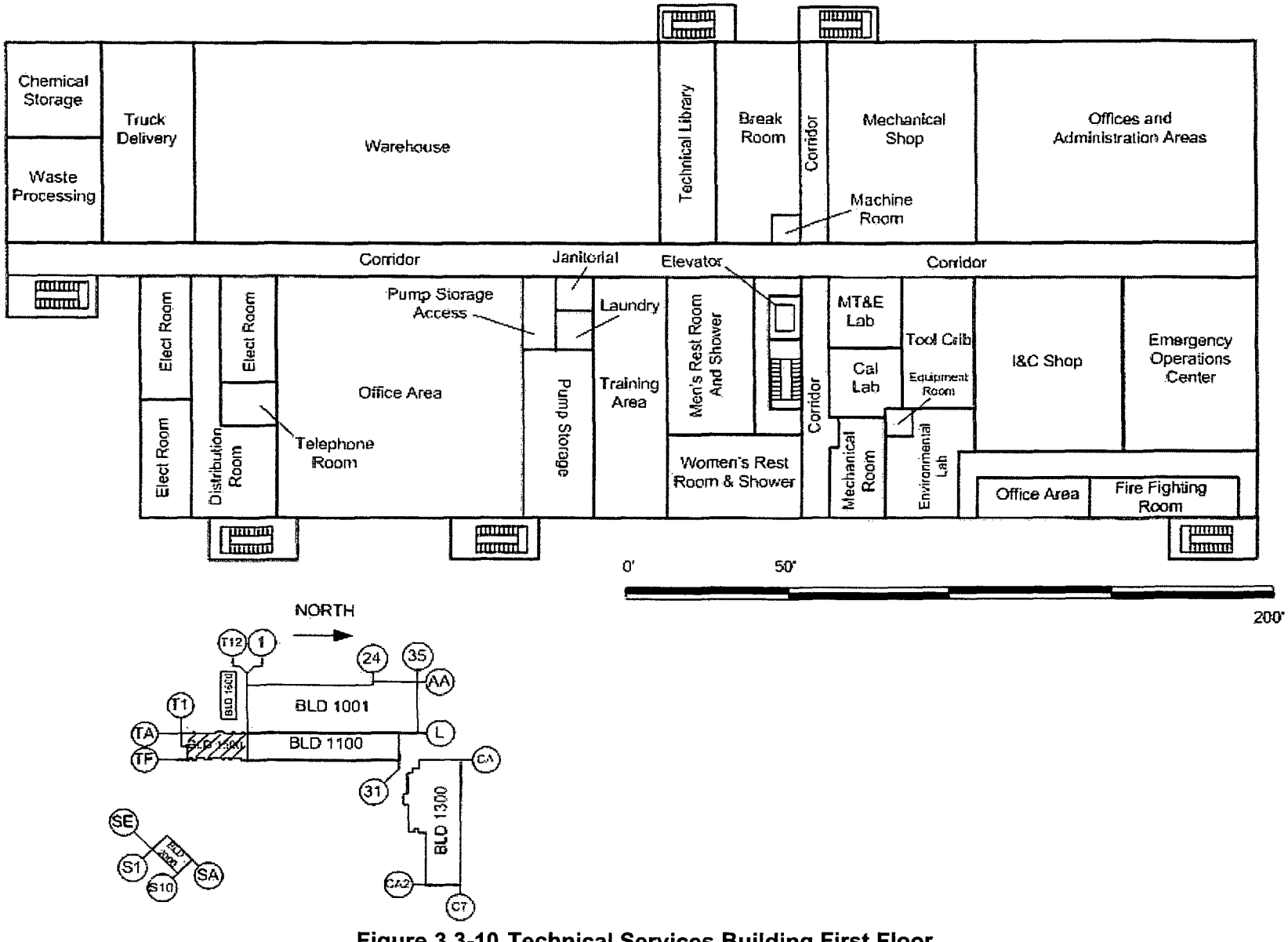


Figure 3.3-10 Technical Services Building First Floor

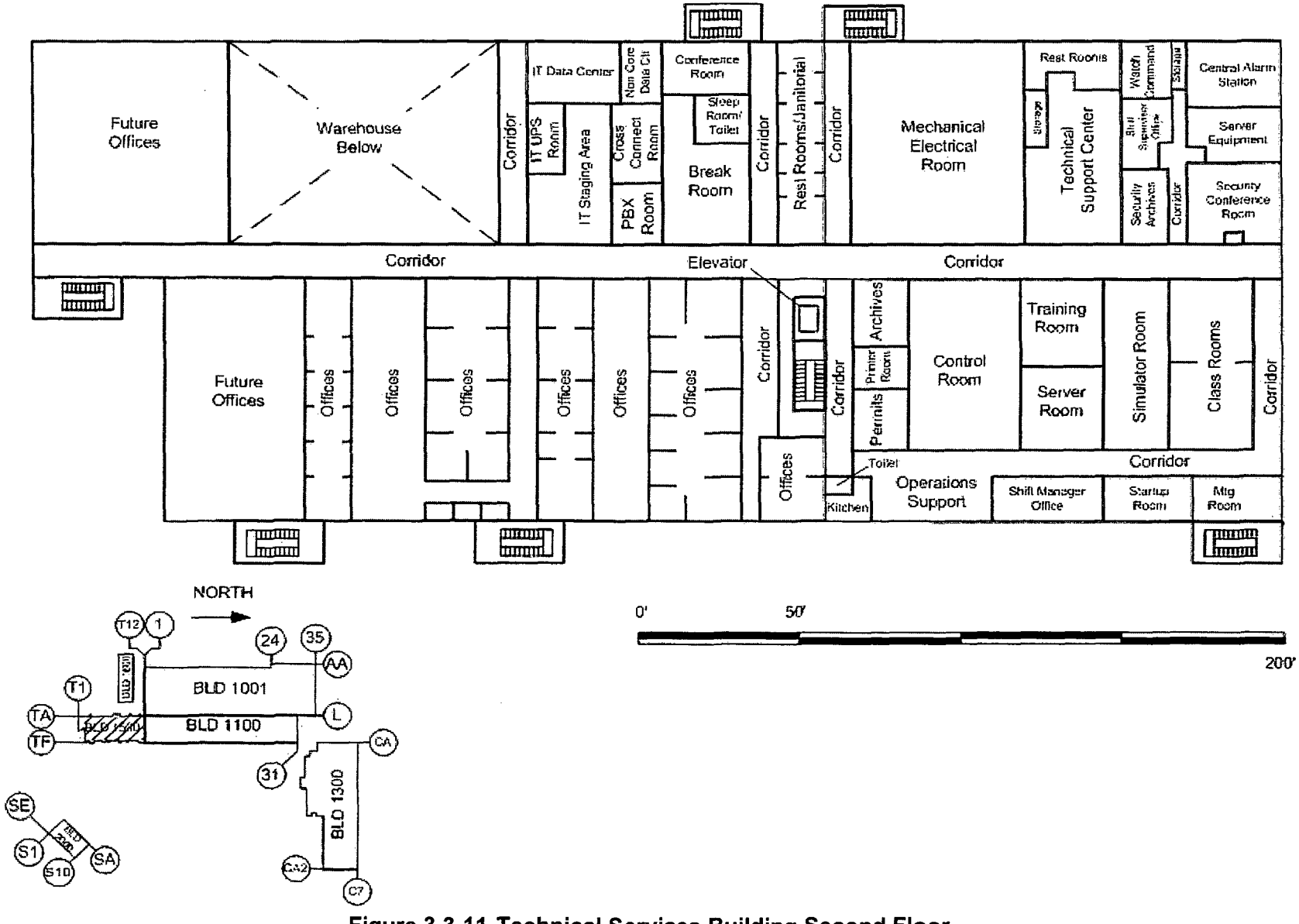
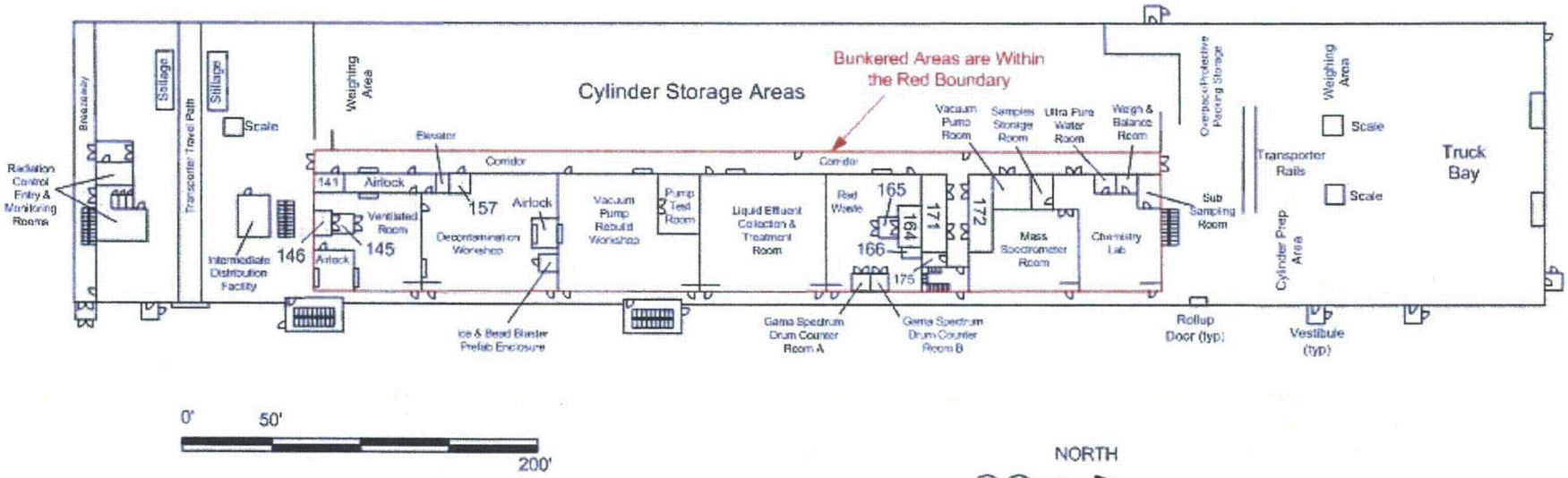


Figure 3.3-11 Technical Services Building Second Floor



Room No.	Description
141	Personnel Decontamination Room
145	Cold Trap and Filter Unit Enclosure
146	Trap Emptying and Drum Tipper Enclosure
157	Elevator Equipment Room
164	Drum Repackaging Enclosure
165	Whole Body Monitor Enclosure
166	Radioactive Source Storage Enclosure
171	Electrical Equipment Room A
172	Electrical Equipment Room B
175	Electrical and Mechanical Chase

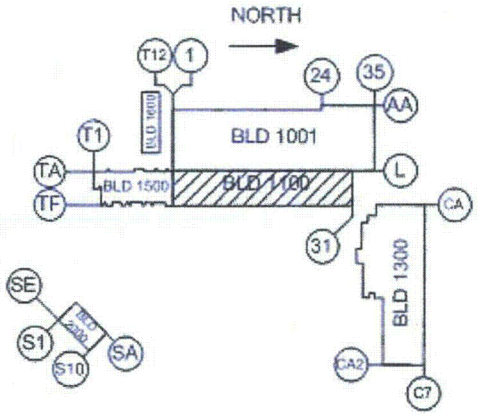


Figure 3.3-12 Cylinder Receipt and Dispatch Building First Floor

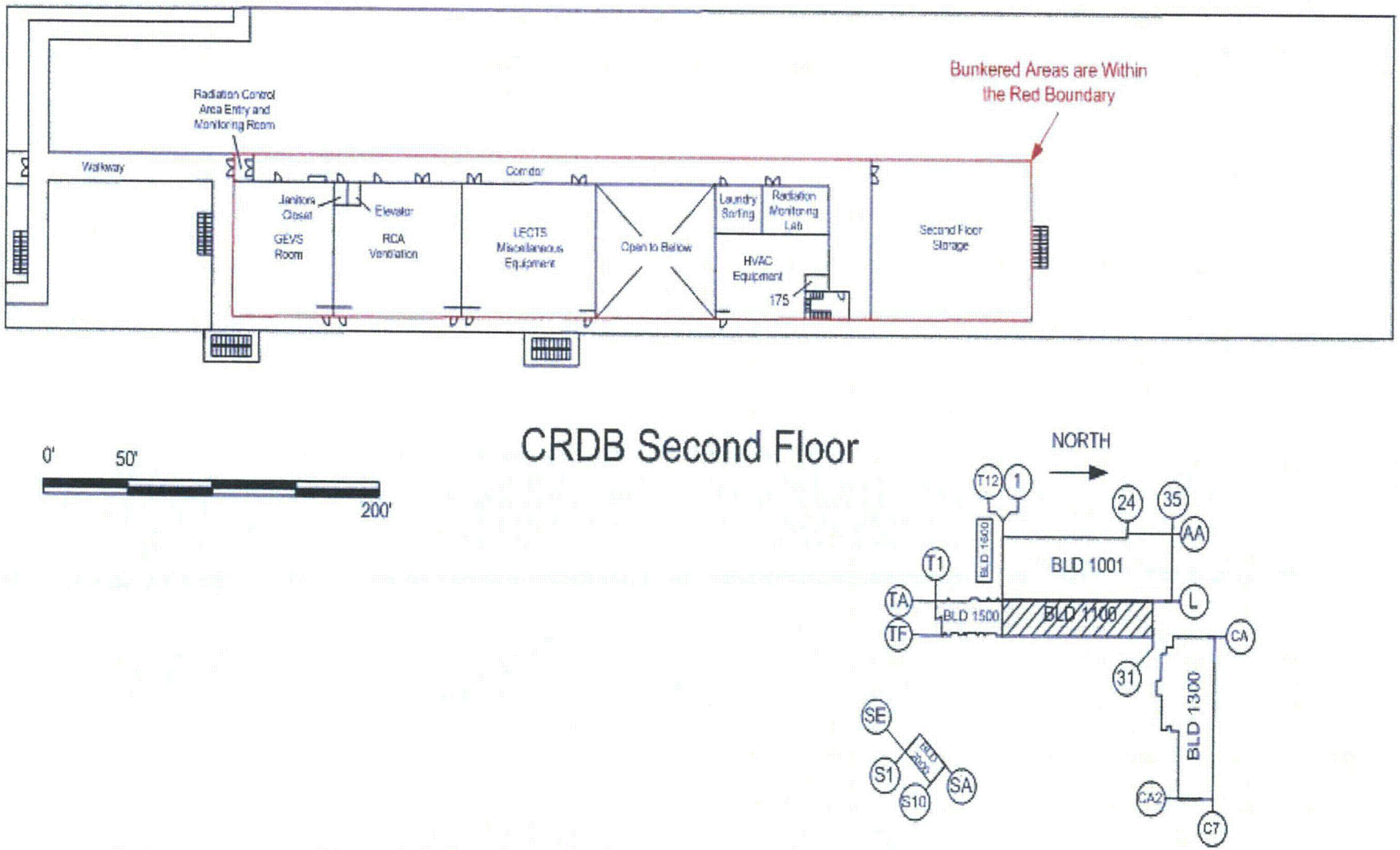


Figure 3.3-13 Cylinder Receipt and Dispatch Building Second Floor

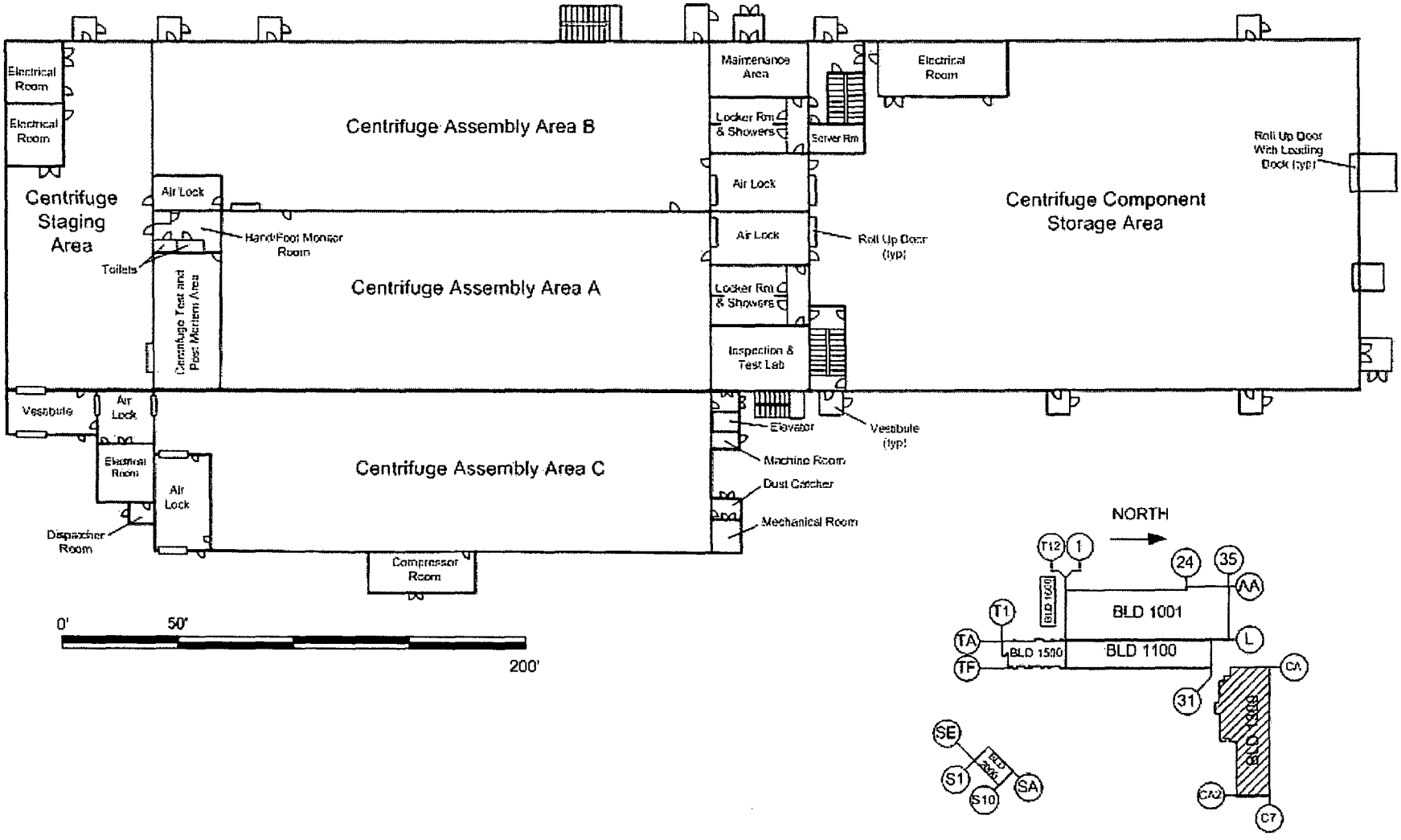


Figure 3.3-14 Centrifuge Assembly Building First Floor

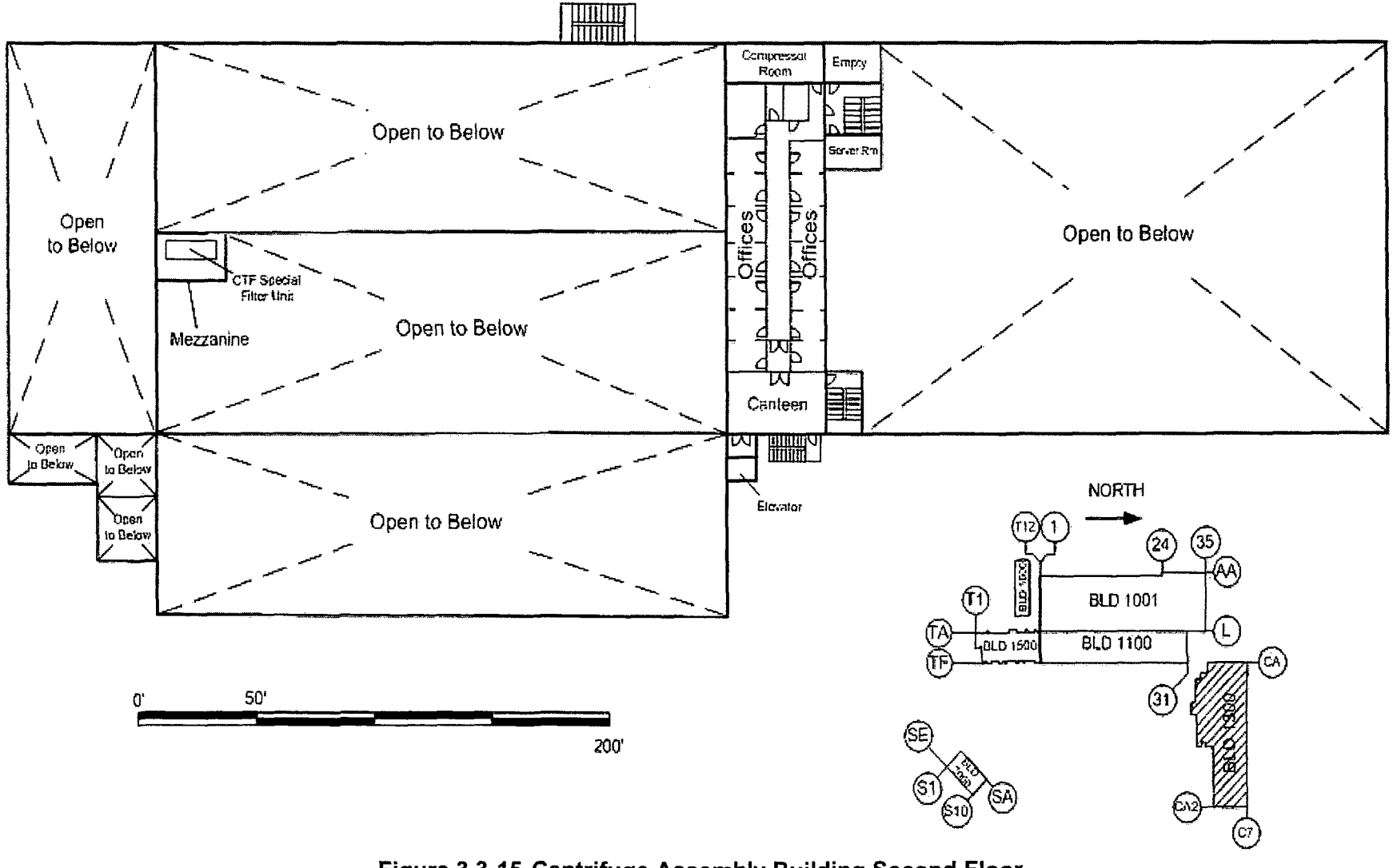


Figure 3.3-15 Centrifuge Assembly Building Second Floor

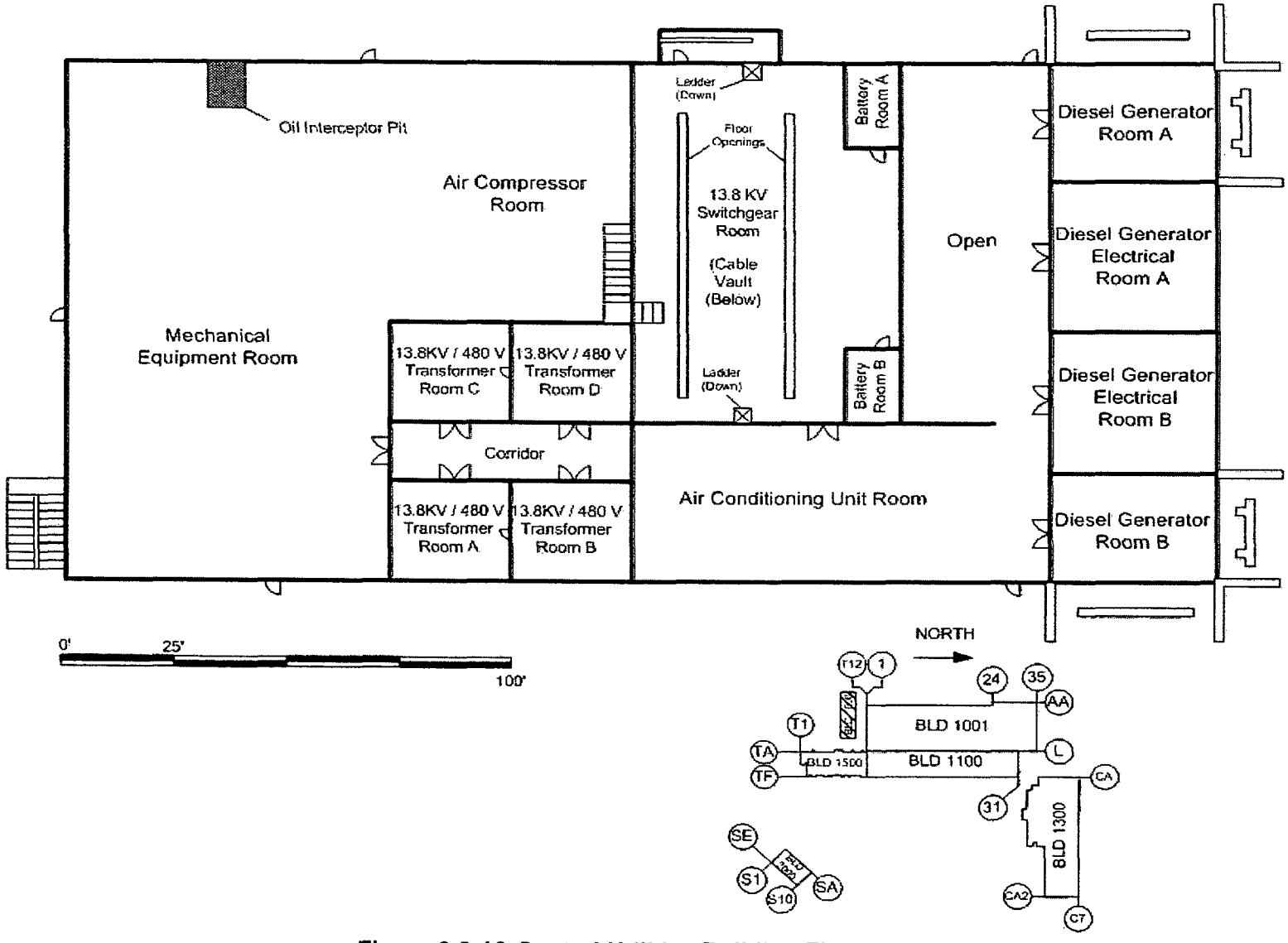


Figure 3.3-16 Central Utilities Building First Floor

3.4 PROCESS DESCRIPTIONS

This section provides a description of the enrichment processes and systems analyzed as part of the Integrated Safety Analysis. A brief overview of the entire enrichment process is provided followed by a detailed description of each process system. This section provides design, operational, and process flow information to support the hazard and accident analysis, as well as to assist in understanding the overall design and function of the National Enrichment Facility (NEF).

UF_6 enrichment systems are comprised of four major systems:

- UF_6 Feed System
- Cascade System
- Product Take-off System
- Tails Take-off System.

In addition to the four primary systems listed above, the following major support systems are discussed in this section:

- Product Blending System
- Product Liquid Sampling System
- Contingency Dump System.

Finally, the following processes and systems are discussed based on their supporting relationship to the enrichment process and the handling of UF_6:

- GEVS
- Centrifuge Test Facility and Centrifuge Post Mortem Facility
- Material Handling.

Each of the sections that discuss the 10 processes identified above are generally organized to present the following information:

- Functional Description
- Major Components
- Design Description
- Interfaces
- Design and Safety Features
- Operating Limits
- Instrumentation

Items relied on for safety associated with the processes and systems identified above are listed in Section 3.8, Items Relied On For Safety (IROFS).

The calculated values of k_{eff} provided in the following sections were obtained using the criticality code MONK8A (SA, 2001), in conjunction with the JEF2.2 nuclear data library. All values of k_{eff} given in the following sections are equal to $k_{calc} + 3\ \sigma_{calc}$ with a safety limit of 0.95.

In the following sections, the design process parameter values are specified with a datum of standard atmospheric pressure at sea level. These values will be finalized to reflect the site-specific NEF elevation during the design phase and the ISA Summary will be revised accordingly.

3.4.1 Overview Of Gas Centrifuge Enrichment Process

The function of the NEF is to enrich (increase) the amount of ^{235}U isotope in uranium hexafluoride (UF_6) from naturally occurring feed at 0.711 $^{w}/_{o}$ up to a maximum of 5.0 $^{w}/_{o}$. The enriched UF_6 is then used for manufacturing fuel for commercial electricity generating nuclear power plants.

An overview of the enrichment process (Ref. Figure 3.4-1, Pictorial Representation of the Enrichment Process) systems and the enrichment support systems are discussed below. Additional details on each of the enrichment process systems are provided in subsequent sections.

3.4.1.1 UF_6 Feed System

(See SAR § 12.2.2.1) The first step in the process is the receipt of the feed cylinders and preparation to feed the UF_6 into the enrichment process.

Natural UF_6 feed is received at the NEF in Department of Transportation (DOT) 7A, Type A cylinders from a conversion plant. The cylinders are ANSI N14.1, 48Y cylinders. Pressure in the feed cylinders is below atmospheric (vacuum) and the UF_6 is in solid form.

The function of the UF_6 Feed System is to provide a continuous supply of gaseous UF_6 from the feed cylinders to the cascades.

To begin the enrichment process, a 48-in feed cylinder is placed into a Solid Feed Station. There are five Solid Feed Stations per Cascade Hall, with four supporting the current SWU capacity and the fifth to support the planned SBM expansion and operational flexibility. Normally three are online. Each Solid Feed Station consists of an insulated enclosure, heated by electric heaters, into which the cylinder is placed. The cylinder is heated to 53°C (127°F) in the Solid Feed Station. At this temperature and pressure (sub-atmospheric), the solid UF_6 sublimes into a gas. Two important safety features of the feed system are that (1) at no time does the UF_6 go into a liquid phase and (2) station design features prevent a 30B product cylinder from being connected to the feed system, thereby eliminating the potential for a criticality event based on over-enrichment of the material in a 30B product cylinder.

The feed purification system is used to remove the light gas components from the UF_6 feed material to a specified level prior to admittance to the cascades. This protects the centrifuges against high intake of light gas and enhances cascade efficiency by limiting impurities.

For each Cascade Hall, there are two feed purification Low Temperature Take-off Stations (LTTS). These stations consist of insulated enclosures that are maintained at operating temperatures by electrically operated chiller units. 48Y cylinders are placed into the LTTS and chilled . As the gaseous UF_6 enters the cylinder, desublimation into solid UF_6 occurs. In addition to the LTTS, there are two UF_6 Cold Traps which desublime UF_6, carbon traps, aluminum oxide (Al_2O_3) traps, and vacuum pumps, used to transfer residual light gas to the Pumped Extract GEVS . The carbon and aluminum oxide traps remove trace UF_6 and HF from the gas stream.

After purification, the UF_6 gas is then fed through a main header to the cascades, where the enrichment process actually occurs. Main header pressure is limited to 65 mbar (26.1 in. H_2O) to prevent the gaseous UF_6 from desubliming back to a solid at ambient temperature.

3.4.1.2 Cascade System

(See SAR § 12.2.2.2) The function of the Cascade System is to receive gaseous UF_6 from the UF_6 Feed System and enrich the ^{235}U isotope in the UF_6 to a maximum of 5 $^{w}/_{o}$.

Multiple gas centrifuges make up arrays called cascades. The cascades separate gaseous UF_6 feed with a natural uranium isotopic concentration into two process flow streams – product and tails. The product stream is enriched in the ^{235}U isotope. The tails stream is depleted in the ^{235}U isotope.

3.4.1.3 Product Take-off System

(See SAR § 12.2.2.3) The function of the Product Take-off System is to provide continuous withdrawal of the enriched gaseous UF_6 product from the cascades.

The product streams leaving the cascades (at each Cascade Hall) are brought together into one common manifold. The product stream is transported via a train of vacuum pumps to Product Low Temperature Take-off Stations. There are five Product LTTS per Cascade Hall. Normally two are on-line when using 30B cylinders. Each LTTS consists of an insulated enclosure that is maintained at operating temperature by electrically operated chiller units. A 30B cylinder is placed into the LTTS and cooled. The 30B cylinders contain final product to be shipped to the customer. The 30B cylinders are used internal to the plant for blending purposes. As the enriched gaseous UF_6 enters the cylinder, desublimation into solid UF_6 occurs. An important safety feature of the Product Take-Off Stations is the design features that prevent using a 48-inch cylinder to collect product material. This eliminates the potential for a criticality event based on over-enrichment if the 48-inch cylinder with enriched product material was inadvertently used as a feed cylinder.

The entire system operates at sub-atmospheric pressure.

The Product Take-off System also contains a system to purge and dispose of light gas impurities from the enrichment process. This system consists of product vent UF_6 Cold Traps into which UF_6 desublimes while leaving the light gas in a gaseous state. The UF_6 Cold Trap is followed by product vent vacuum pump/chemical trap sets, each consisting of an activated carbon trap, two aluminum oxide traps, and a vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. The carbon trap removes small traces of UF_6 and the aluminum oxide trap removes any HF from the gas flow. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

There are connections to the Assay Sampling System and the On-line Mass Spectrometer System for product sampling and analysis.

3.4.1.4 Tails Take-off System

(See SAR § 12.2.2.4) The primary function of the Tails Take-off System is to provide continuous withdrawal of the gaseous UF_6 tails from the cascades. A secondary function of this system is to provide a means for removal of UF_6 from the centrifuge cascades under abnormal conditions.

The tails stream exits each cascade through a primary header, goes through a pumping train, and then to Tails Low Temperature Take-off Stations. There are eleven Tails Low Temperature Take-off Stations per Cascade Hall,with eight supporting the current SWU capacity and three additional stations to support the planned SBM and operational flexibility. Under normal operation, typically seven of the LTTS are in operation receiving tails and one is on standby.

Each Low Temperature Take-off Station consists of an insulated enclosure that is maintained at –25°C (-13°F) by electrically operated chiller units. 48Y cylinders are placed into the LTTS and cooled. As the gaseous depleted UF_6 (tails) enters the cylinder, it desublimes into solid UF_6.

The entire system operates at sub-atmospheric pressure.

The Tails Take-off System also has an evacuation pump/chemical trap set, and connections to the Assay Sampling Subsystem and an On-line Mass Spectrometer System for continuous gas sampling.

3.4.1.5 Product Blending System

(See SAR § 12.2.2.5) The primary function of the Product Blending System is to provide means to fill 30B cylinders with UF_6 at a specific enrichment of ^{235}U to meet customer requirements. This is accomplished by blending (mixing) UF_6 at two different enrichment levels to one specific enrichment level. The Product Blending System can also be used to transfer product from a 30B cylinder to another 30B cylinder without blending.

The Product Blending System is sized for the complete 3,000,000 SWU/yr enrichment plant production.

This system consists of Blending Donor Stations (which are similar to the Solid Feed Stations) and Low Temperature Take-off Blending Receiver Stations (which are similar to the LTTS described earlier).

The donor system consists of two Blending Donor Stations. Each station consists of an insulated enclosure (similar to the Solid Feed Station enclosures). Full 30B product cylinders at various enrichment levels are placed into the Blending Donor Stations and are heated to sublime the solid UF_6 to gas. Sublimed gas from the two Blending Donor Stations is transported to two Blending Receiver Stations.

Each Blending Receiver Station consists of an insulated enclosure that is maintained at the desired temperature by electrically operated chiller units. Empty 30B cylinders are placed into the station and cooled to. As the gaseous UF_6 from the Blending Donor Stations enters the cylinder, desublimation into solid UF_6 occurs. An important safety feature of the Blending Receiver Stations is the station design features that prevent using a 48-inch cylinder to collect product material. This eliminated the potential for a criticality event based on over-enrichment if the 48-inch cylinder with enriched product material was inadvertently used as a feed cylinder.

There are no vacuum pumps used to transfer product in this system. The Product Blending System has a vent system similar to the product vent system.

3.4.1.6 Product Liquid Sampling System

(See SAR § 12.2.2.6) The function of the Product Liquid Sampling System is to obtain a representative assay sample from filled product cylinders. The sample is used to validate the exact enrichment level and quality of UF_6 in the filled product cylinders, before the cylinders are sent to the fuel processor.

The Product Liquid Sampling System and Sub-Sampling System (Section 3.5.18) are the two systems at NEF that change solid UF_6 to liquid UF_6. The main piece of equipment used in this system is the Product Liquid Sampling Autoclave. A filled 30B product cylinder is placed into the autoclave and a manifold (inside the autoclave), which can support up to three sample bottles, is connected to the 30B cylinder valve. After closing the autoclave door, the autoclave is heated by air heated with electric heaters. As the temperature of the UF_6 in the cylinder increases, the pressure also increases. When the pressure in the sample manifold reachesa pre-designated pressure, the temperature is stabilized. At this point, the UF_6 is a liquid. In order to assure that a sample represents the entire contents of the cylinder, it is necessary to homogenize the UF_6. The UF_6 will homogenize when the UF_6 becomes liquid at the high pressure and temperature. Homogenization typically lasts for 16 hours. After the homogenization period, the sampling process is initiated.

After homogenization, with the sample bottle valves closed, the autoclave is tilted via a tilting mechanism to 30 degrees from horizontal. After the sample manifold is filled, the autoclave is lowered to horizontal, and the sample bottle valves are opened and closed in sequence to collect the liquid samples. The autoclave and cylinder is then cooled down and the autoclave is vented and opened for sample bottle removal.

One of the main safety features of the autoclave is that it is designed to provide a secondary confinement barrier in the unlikely event a leak should occur in the UF_6 cylinder or connected piping while the UF_6 is in liquid form. Numerous controls are designed into the autoclave to mitigate overheating and other conditions that may affect the integrity of the UF_6 system.

3.4.1.7 Passivation Activity

The passivation activity occurs in the UF_6 Feed System (including Feed Purification System), Tails Takeoff System and Product Takeoff Systems and prior to connecting the systems to the cascades. This activity is performed to remove moisture and inherent hydrocarbon residue in the process systems caused by construction activity. Following nitrogen purging, evacuation and helium leak checks to the systems, the systems are passivated by introducing a controlled amount of UF_6 into the systems to react with the moisture and hydrocarbon residue.

3.4.2 (See SAR § 12.2.2.1)UF_6 Feed System

3.4.2.1 Functional Description

The principal function of the UF_6 Feed System is to provide a continuous supply of gaseous uranium hexafluoride (UF_6) from the feed cylinders to the cascades (Ref. Figure 3.3-3, UF_6 Handling Area, Equipment Locations and 3.4-2, Process Flow Diagram, UF_6 Feed System). Sublimation from the solid phase, at pressures significantly below atmospheric, is the process used in the UF_6 Feed System. Purification of the as-received UF_6 feed material is accomplished in the Feed Purification Subsystem, where light gas components, primarily air and HF, are removed. This protects the centrifuges against excessive intake of light gas, which improves cascade production efficiency. Secondary functions of the Feed Purification Subsystem are to vent the light gas from the system during cylinder changeouts and to remove the final quantity of UF_6 (the heel) from the feed cylinder. The system produces intermittent gaseous effluent from UF_6 purification operations. Additional small intermittent quantities of gaseous effluent are produced from purging and evacuating the flexible piping used to connect the feed and feed purification cylinders. These effluents are treated by the Feed Purification UF_6 Cold Traps and Vacuum Pump/Chemical Trap Sets to remove UF_6 and HF before being routed to the Pumped Extract GEVS ExtractGEVS for further treatment. Solid wastes are produced from periodic change-out of chemical and oil traps. There are no liquid effluents directly produced in this system. Vacuum pumps are taken out of service for maintenance and the pump oil is reprocessed in the CRDB and reused.

The UF_6 Feed Systems are located in the UF_6 Handling Area of each SBM. The UF_6 Feed Systems are operated from the Control Room, with the exception of maintenance and preparation activities, which are controlled locally.

3.4.2.2 Major Components

The major UF_6 Feed System components are described below.

A. Solid Feed Station.

A Solid Feed Station (Ref. Figure 3.4-3, Solid Feed Station Equipment Drawing) consists of an insulated box with a non-flammable core, complete with rails for the electric carriage of the cylinder transporter. Each Solid Feed Station uses an electric air heater and circulation fan, to heat solid UF_6 causing it to sublime within the cylinder. A Solid Feed Station weighing device (a frame with four load cells) provides continuous on-line weighing of UF_6 in the feed cylinder.

The front of the Solid Feed Station is made up of a single door. Connection of the cylinder in a Solid Feed Station is made at the front (door) end. The Solid Feed Station does not have a rear opening. Rubber seals are used on the openings in the Solid Feed Station to minimize leaks for energy conservation.

B. Solid Feed Station Valve Hotbox.

Valves in a Solid Feed Station Valve Hotbox connect the feed cylinder to the Main Feed Header, the Feed Purification Subsystem, or the Nitrogen System. Manual and automatic isolation valves, a pressure control valve, and pressure transducers are contained in the electrically heated hotboxes to maintain them at a stable temperature. The UF_6 piping between the Solid Feed Station and hotbox is heat traced.

C. Main Feed Header.

The Main Feed Header connects the Solid Feed Station Valve Hotboxes to each of the cascades in a Cascade Hall. Pressure is controlled in the header so that heat tracing is not required.

D. Feed Purification Subsystem.

A Feed Purification Subsystem is provided for each Cascade Hall and consists of two Low Temperature Take-off Stations (LTTS), each with associated valve hotbox, UF_6 cold trap and heater chiller unit, and a vacuum pump/chemical trap set. One Feed Purification Subsystem is provided for each Cascade Hall, but each major component in the system is duplicated. The major Feed Purification Subsystem components are described below:

1. Low Temperature Take-off Station (LTTS) (Ref. Figure 3.4-4, Low Temperature Take-off Station Equipment Drawing). An LTTS consists of a composite panel box construction complete with rails for the electric carriage of the cylinder transporter. The LTTS panels have a non-flammable insulated core and are vapor sealed to prevent ice build-up within the insulation. Each LTTS incorporates an air chiller unit, with controls, to remove thermal energy from the UF_6 gas to cause it to desublime in the cylinder. The chiller unit uses a heater during the defrost cycle, to prevent ice buildup on the coils. The cylinder valve and inlet piping are electrically heated to prevent UF_6 from desubliming and blocking the cylinder inlet. An LTTS weighing device (a frame with four load cells) provides continuous on-line weighing of UF_6 in the purification cylinder.

   The front of the LTTS is made up of a single door and the back is furnished with an opening to facilitate connection of the cylinder to the UF_6 piping. Seals on the openings in the LTTS minimize leaks for energy conservation. The LTTS access openings are provided with heat tracing to prevent ice build-up.

2. Low Temperature Take-off Station Valve Hotbox. Valves in a LTTS valve hotbox connect the LTTS to the Solid Feed Station Valve Hotboxes, the UF_6 cold traps, or the Nitrogen System. Manual and automatic isolation valves and a pressure transducer are contained in the electrically heated hotboxes to maintain them at a stable temperature. The UF_6 piping between the Solid Feed Station Valve Hotboxes and the LTTS Valve Hotboxes is heat traced.

3. UF_6 Cold Trap (Ref. Figure 3.4-5, UF_6 Cold Trap Equipment Drawing). Each UF_6 cold trap consists of an insulated horizontal tube with internal baffles. The UF_6 cold trap has a dedicated heater/chiller unit operating at a cooling set point and a heating set point. Each heater/chiller unit contains a heat exchange media [approximately 70 L (19 gal) of silicon oil]which circulates around each cold trap. The low temperature removes the thermal energy from the UF_6 gas, causing it to desublime on the internal walls of the trap, while leaving the light gas in the gaseous phase. The high temperature results in sublimation of the UF_6 contents of the UF_6 cold trap for transfer back to a feed purification cylinder. Each end of the UF_6 cold trap is heat traced to prevent the UF_6 from solidifying and blocking the UF_6 cold trap entrance or exit. The UF_6 cold trap has a weighing device to provide continuous on-line weighing of the UF_6 accumulated.

   An automatic control valve located after each UF_6 cold trap restricts the flow of gases through the UF_6 cold traps. This ensures an adequate residence time for the gases in the UF_6 cold trap to allow all of the UF_6 to desublime.

4. Vacuum Pump/Chemical Trap Set (Figure 3.4-6, Chemical Trap Equipment Drawing). The UF_6 cold traps are followed by vacuum pump/chemical trap sets. Each set has an activated carbon trap, two aluminum oxide traps, an insulated vacuum pump with nitrogen purge, and an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. The vacuum pump exhausts into the Pumped Extract GEVS. The activated carbon trap removes small traces of UF_6. The aluminum oxide trap removes HF. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

E. Mobile Feed Sampling Rig

The Mobile Feed Sampling Rig is used to take UF_6 process samples from feed cylinders prior to UF_6 material being introduced into the cascades. Once the required samples are taken the rig will be evacuated through a chemical trap and pump for removal of any remaining UF_6 and HF and exhausted to the Pumped Extract GEVS. The Mobile Feed Sampling Rig is comprised of automatic and manual valves, nitrogen purging, and an evacuation pump/trap set, where the trap consists of a mixed-bed containing both activated carbon and aluminum oxide. An aluminum oxide oil trap is on the pump suction and a mechanical oil trap (exhaust filter) is on the pump discharge. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS. This pump/trap set also contains a flow restriction device (IROFSC21) on the suction side of the pump. A temperature instrument prevents the mixed-bed trap from overheating. The sensor monitors the mixed-bed trap temperature. If the high temperature trap setpoint is reached, an alarm is activated.

F. Helium Leak Test Cart

The Helium Leak Test Cart connects to piping systems in the feed, tails or product stream that has been isolated for testing. The Helium Leak Test Cart is required to evacuate air and/or nitrogen from the isolated portion of the system and allow a vacuum to be drawn to enable leak testing of pipe and valves. This leak detection method is used to implement ASME Code Case 185 as an alternative to ASME B31.3 testing for process piping. The Helium Leak Test Cart is comprised of automatic and manual valves, cold trap, helium leak detector, helium bottle, vacuum pump, an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

Although the Helium Leak Test Cart is described here in the feed system section, it should be noted that it is used throughout the UF_6 process system e.g., product, tails, product blending and contingency dump systems. For discussion of the criticality evaluation for this cart see Section 3.4.4.8.10.

3.4.2.3 Design Description

The design bases and specifications are given in Table 3.4-1, UF_6 Feed System Design Basis. Applicable Codes and Standards are given in Table 3.4-2, UF_6 Feed System Codes and Standards.

The entire UF_6 Feed System operates at sub-atmospheric pressure. In the event of a confinement barrier failure (e.g., pipe leak), releases of uranyl fluoride (UO_2F_2) and HF are greatly minimized because air will migrate into the system rather than UF_6 escaping from the system. This important safety feature greatly limits the likelihood of exposures.

There are five Solid Feed Stations, each with an associated valve hot box, connected in parallel to the main feed header in each UF_6 Feed System. At any time three Solid Feed Stations can be on-line to handle the maximum UF_6 feed flow to one Cascade Hall. The remaining Solid Feed Stations can be in either standby, off-line, preparation, or maintenance mode.

Each UF_6 Feed System has a dedicated Feed Purification Subsystem, consisting of two LTTSs, two UF_6 Cold Traps, and two Vacuum Pump/Chemical Trap Sets connected in parallel. One of the LTTSs, UF_6 Cold Traps, and Vacuum Pump/Chemical Trap Sets is available for use, while the second is a spare and can be in, off-line, preparation (cylinder being installed or removed), or maintenance mode.

Prior to feeding UF_6 to the cascades, the contents of each cylinder are purified and verified as natural UF_6. This verification is accomplished by sampling and assay analysis of a feed cylinder contents for uranic enrichment. Any light gases, primarily air and HF, and a specified quantity of UF_6 are transferred to a purification cylinder, to ensure that impurities are removed from the feed cylinder. Likewise, the purification cylinder is relieved through the UF_6 Cold Trap and Vacuum Pump/Chemical Trap Set to the Pumped Extract GEVS. Finally a sample of the gaseous UF_6 is desublimed into a sample bottle for analysis.

The Solid Feed Station provides controlled heat to the feed cylinder to sublime the UF_6 directly from solid phase to gaseous phase at subatmospheric pressures. Pressure is controlled throughout the system to maintain the sub-atmospheric pressures and to provide the required flow rate. UF_6 piping and valve stations where UF_6 desublimation could occur are heated. The building HVAC system is designed to maintain a minimum temperature of 18°C (64.4°F), therefore heat tracing of the main feed header, which is controlled at a pressure less than 65 mbar (26.1 in. H_2O), is not required.

All components and piping in the UF_6 Feed System operate at subatmospheric pressure. Release of UF_6 and/or HF is unlikely because leakage, if it were to occur, would be into the system.

The materials of construction and fabrication specifications for the equipment and piping used in the UF_6 Feed System are compatible with UF_6 at the operating conditions and have been proven by over 30 years of use in existing Urenco European enrichment plants.

3.4.2.4 Interfaces

The UF_6 Feed System interfaces with the following systems and utilities:

A. Cascade System
B. Pumped Extract GEVS
C. Nitrogen System
D. Compressed Air System
E. Electrical System
F. Plant Control System
G. Hoisting and Transportation Equipment.

3.4.2.5 Design and Safety Features

The UF_6 Feed System is designed and constructed to provide safe operation for plant personnel as well as the general public. Principal design features are as follows:

A. All process piping, valves, vessels and pumps in the UF_6 Feed System operate at sub-atmospheric pressure.
B. Piping is all welded construction and process valves are bellows sealed.
C. Before disconnecting any equipment, the process piping is evacuated and purged with nitrogen.
D. A local exhaust to the Pumped Extract GEVS is provided for initial plant operations via a temporary local extract cross-connection any time a UF_6 line is disconnected.
E. Before discharge to the Pumped Extract GEVS, all gases flow across activated carbon and aluminum oxide in the Feed Purification Subsystem vacuum pump/chemical trap set to remove any traces of UF_6 and HF.
F. Temperature in each Solid Feed Station and LTTS is monitored and controlled.
G. Feed purification cylinder overfill is prevented by two weight trips. The first is at the desired net weight of UF_6 and the second is at the gross weight of the cylinder with UF_6 contents. Only the first trip is operator adjustable.

H. Hydrocarbon lubricants are not used. The Feed Purification vacuum pumps are lubricated with perfluorinated polyether (PFPE) oil, a fully fluorinated synthetic oil.

I. Removal of a connected cylinder from an LTTS is prevented by an interlock system. Unless the flexible hose on the cylinder valve has been removed and locked in its "holster," a physical barrier prevents the cylinder transporter drawbridge from docking with the station rails, thereby preventing cylinder removal.

J. Temperature in the Feed Purification Subsystem carbon trap is monitored and controlled.

K. Should a blockage occur in a section of UF_6 Feed System process piping, the heat tracing on that section of pipe is not allowed to be switched on until the solid UF_6 has been removed.

L. Mechanical interlocking systems are provided in all solid feed and low temperature stations to prevent the operation of the stations loaded with an incorrect cylinder type . The system prevents the use of cylinders identified for product take-off from being used in either a solid feed station or feed purification station.

3.4.2.6 Operating Limits

The UF_6 Feed System must provide purified feed to the cascades at the minimum and maximum rates under normal operating conditions.

3.4.2.7 Instrumentation

The process variables, such as pressure, temperature, and valve positions, are automatically controlled. Deviations from specified values are detected and indicated via a two level alarm system. At the first alarm, the operator has the ability to manipulate the process to restore it to normal. A second alarm, automatic action is taken to provide system protection. For safety, system protection, and operability, some sensors are duplicated and others are installed in triplicate. Action is initiated if any one out of two or three sensors reach alarms.

A. Solid Feed Station

Solid Feed Station air temperature and cylinder temperature are monitored to prevent feed cylinder over pressurization due to overheating. Normal air temperature in the Solid Feed Station during heating ranges from ambient to 61°C (142°F), while the cylinder temperature ranges from ambient to 55°C (131°F). An alarm gives the operator warning of high temperature. A second alarm trips the Solid Feed Station heater off.

In addition to the temperature controls, the Solid Feed Station has two independent and diverse temperature protection instruments (Items Relied on For Safety (IROFS)). One is fail-safe hard wired Resistance Temperature Detector (RTD), and the other IROFS is a fail-safe thermocouple. Both instruments measure the Solid Feed Station air temperature. Both instruments automatically de-energize the air heater and blower if the Solid Feed Station air temperature rises above their set point. To ensure cylinder integrity both instruments are set to trip at a set point which is well below the calculated set point.

The feed cylinder pressure is monitored with dual sensors to prevent over pressurization of the cylinder, piping, and valves. The first alarm gives the operator warning of over pressure. The second alarm automatically closes the cylinder valve and trips the Solid Feed Station off-line, which de-energizes the air heaters and blower.

Each Solid Feed Station has a weighing system to monitor the contents of the feed cylinder. A weight trip set at 800 kg (1,764 lb) gross is used to indicate a cylinder is present in the Solid Feed Station. A second weight trip, equal to a net UF_6 weight of 100 kg (221 lb), indicates the cylinder is empty and puts the Solid Feed Station in standby.

B. Solid Feed Station Valve Hotbox

A single pressure transducer is located in the piping in each Solid Feed Station Valve Hotbox. When selected to control the Solid Feed Station, the pressure transducer is used to modulate the Solid Feed Station feed control valve. A first alarm warns the operator of high pressure. A second alarm automatically switches the Solid Feed Station to standby and closes the outlet valve.

Low feed pressure is also alarmed. The first alarm warns the operator of loss of feed supply. A second alarm indicates the feed cylinder is empty.

C. Main Feed Header

Two pressure transducers are located in the main feed header near the Solid Feed Stations. When selected to control a Solid Feed Station, one of two pressure transducers is used to modulate the Solid Feed Station feed control valve. An alarm warns the operator of high pressure. A second alarm automatically switches all of the Solid Feed Stations to standby and closes each Solid Feed Station's outlet valve. A low alarm atwarns the operator of loss of feed supply.

In addition, three pressure transducers are evenly distributed along the feed header near the cascades. These act on a one out of three basis to protect the cascades from abnormal pressures. A high alarm warns the operator of high pressure. A second high alarm automatically prevents feeding into the cascades. A low alarm warns of loss of the feed supply. A second low alarm automatically prevents feeding into the cascades.

D. Feed Purification Low Temperature Take-off Stations

The purification cylinder inlet pressure is monitored to assure that a cylinder is connected to the system. Normal pressure is <250 mbar (<100 in. H_2O). An alarm warns of high pressure. A second alarm closes the LTTS Valve Hotbox inlet valve and the LTTS is tripped to standby. At a pressure determined by the system description documents the cylinder is available for feed purification, and below a still lower pressure determined by the system description document it is available for feed cylinder heel removal.

Each LTTS has a weighing system to monitor the contents of the purification cylinder. The first alarm is 8,500 kg (18,743 lb) net weight for a 48Y type cylinder, above which efficiency is reduced. At 12,400 kg (27,342 lb), the maximum operational net weight for a 48Y type cylinder, the LTTS trips to standby and the inlet valve closes. A second trip at 15,300 kg (33,737 lb) gross weight for a 48Y type cylinder also closes the inlet valve and trips the LTTS off-line. A low alarm at 800 kg (1,764 lb) gross weight indicates no cylinder present in the LTTS. The output of the weighing system also allows cylinder weight to be verified to be within specified trending limits.

For temperature control and protection from high temperatures, the LTTS has a stand-alone control and protection system. The total system consists of three sensors. For main LTTS temperature control, one sensor is mounted in the air return to the chiller unit and monitors the circulating air temperature. This sensor and local control maintains the LTTS temperature. In addition to controlling the LTTS temperature, one output is monitored by the Plant Control System (PCS) and warns when the air temperature rises above the normal operating reange. This would indicate a chiller failure or that the defrost heater is not functioning properly. The LTTS refrigeration unit has a defrost cycle to remove ice from the cooling coils. This is done with a defrost heater at the coils. When the defrost heater is on, the circulating air fan is off to minimize the increase in LTTS air temperature.
In addition to the closed loop control system previously described, there are two independent and diverse temperature protection instruments. These provide extra safety margin to protect against increases in temperature that may occur if the defrost heater control does not operate properly. The first instrument is a fail-safe hardwired RTD and the second instrument is a fail-safe thermocouple. Both instruments measure the temperature of the air inside the LTTS. Both instruments will trip the defrost heater and fan power supply in the event the air temperature rises above their set point. If heater trip occurs from these two instruments, the LTTS is automatically taken off-line and put into a standby mode.Both instruments are set to trip at a set point which is well below the calculated set point required to ensure cylinder integrity.

To prevent desublimation in the cylinder valve, the cylinder valve and inlet piping are electrically heated.

E. Feed Purification UF_6 Cold Traps

Dual pressure instruments monitor the UF_6 cold trap inlet pressure. The instruments have different ranges and each is used during different purification operations.

UF_6 cold trap outlet pressure is monitored during the purification operation. A high alarm warns of high pressure in the UF_6 cold trap. A second high alarm trips the UF_6 cold trap off-line, switching the heater/chiller unit off and closing the inlet and outlet valves. A low alarmwarns of low pressure and indicates the UF_6 cold trap is empty when collected UF_6 is being sublimed for transfer back to a purification cylinder. A second low alarmcloses the UF_6 cold trap outlet valve to prevent UF_6 flow to the vacuum pump.

A pressure sensor and control valve between each UF_6 cold trap and its vacuum pump/chemical trap set restricts the flow of light gases through the UF_6 cold trap to ensure all UF_6 desublimes and does not reach the carbon trap. The line pressure into the vacuum pump/chemical trap set is controlled.

A weighing system monitors the contents of the UF_6 cold trap. An alarm at 40 kg (88.2 lb) warns that the UF_6 cold trap is approaching capacity. A second alarm closes the UF_6 cold trap inlet and outlet valves.

The temperature of the UF_6 cold trap is maintained at –60°C (-76°F) during cooling and at 20°C (68°F) for heating during sublimation to empty the UF_6 cold trap of collected UF_6 (gas back). A low alarm warns of a chiller unit fault. A high alarm closes the UF_6 cold trap outlet valve and a second high alarm warns of high temperature during gas back. If the temperature continues to rise, the UF_6 cold trap trips off-line to avoid desublimation of UF_6 in the header.

F. Feed Purification Vacuum Pump/Chemical Trap Sets

A temperature instrument prevents the carbon trap from overheating The sensor monitors the carbon trap temperature. If the high temperature trip setpoint is reached, a signal is sent to the PCS to warn the operator.

The second (downstream) activated aluminum oxide (Al_2O_3) trap on the vacuum pump/chemical trap set is also equipped with a weigh system. An increase in the weight of the trap indicates the first Al_2O_3 trap is saturated. The weigh system on the aluminum oxide trap displays a weight locally and provides a healthy/unhealthy status to the PCS. There is no control function on this weight indicator. The chemical traps are replaced based on the accumulated weight.

G. (See SAR § 12.2.1.1.5) Mobile Pressure Transducer Calibration Rig

The Mobile Pressure Transducer Calibration Rig is used for the calibration of pressure transducers located throughout the UF_6 process systems that monitor process pressures. The desired pressure transducer is isolated from the process UF_6 gas stream by closing the manual valves located upstream and downstream of the pressure transducer. This rig consists of manual and automatic valves, a number of digital pressure transducers, a pirani-type pressure measurement device, a mixed-bed chemical trap, two rotary vane vacuum pumps, a turbo-molecular vacuum pump, connection for exhaust to the pumped extract GEVS and a self contained nitrogen bottle. An aluminum oxide oil trap is one the pump suction and a mechanical oil trap (exhaust filter) is on the pump discharge. The oil traps prevent oil mitigration both upstream and into the Pumped Extract GEVS. The rig also has a provision that enable the use of the plant nitrogen system. The gaseous nitrogen is used for purging of the system. The mixed-bed trap absorbs any trace amounts of UF_6 and HF gas and remaining light gaseous effluents are vented to the pumped extract GEVS.

This rig contains flow restriction devices (IROFSC21) on the suction side of the pumps. IROFSC21 is applied two different places on this rig. One is in the flow path through the mixed bed trap and the other is in the flow path through the turbo pump. Although the Mobile Pressure Transducer Calibration Rig is described here in the feed system section, it should be noted that it is utilized throughout the UF_6 process system e.g., cascade, product, tails, product blending and contingency dump systems. For discussion of the criticality evaluation for this rig see Section 3.4.4.8.8.

3.4.2.8 Criticality Safety

The feed material used in the feed system is natural UF_6 with 0.711% enrichment. Criticality at this enrichment level is not credible, given the physical law. The only equipment associated with the feed system requiring a criticality evaluation is the Mobile Feed Sampling Rig, as this rig could be inadvertently connected to other parts of the process systems such as the cascade and product take-off systems with the use of an adaptor.

The Mobile Feed Sampling Rig is used to take UF_6 process samples through an inlet hose connected to the feed station hotbox system. Once the required sample are drawn, the rig will be evacuated through a vacuum pump and chemical trap set for removal of any remaining UF_6 and HF. The pump/trap set consists of a mixed-bed chemical trap, a rotary vane vacuum pump, an oil adsorber and an exhaust filter, and is connected to the plant GEVS for venting the exhaust of UF_6 and HF.

The items on the Mobile Feed Sampling Rig are safe by design individually. The Mobile Feed Sampling Rig as a whole is a safe-by-design by physical arrangement as demonstrated in a nuclear criticality safety evaluation through comparison to a bounding calculation performed for the product vent vacuum pump/trap set described in Section 3.4.4.8.3.

3.4.3 (See SAR § 12.2.2.2) Cascade System

3.4.3.1 Functional Description

The function of the Cascade System is to receive gaseous UF_6, with a natural uranium isotopic concentration, from the UF_6 Feed System and separate it into two streams, increasing (enriching) the ^{235}U isotope content in one("product") and decreasing (depleting) the ^{235}U isotope content in the other ("tails") (Ref. Figure 3.4-7, The Enrichment Process, and Figure 3.4-8, Cascade Process Scheme Equipment Drawing). These UF_6 streams flow from arrays of gas centrifuges, called cascades, through headers to the Product Take-off System and Tails Take-off System.

3.4.3.2 Major Components

The major Cascade System components are:

A. Centrifuges

The latest qualified centrifuge, Model TC-12, contains a rotor that is used to produce centrifugal force needed for isotope separation (Ref. Figure 3.4-9, Principle of a Gas Centrifuge). An electromagnetic motor drives the rotor. A stationary center post in the rotor provides the input of UF_6 feed and output of UF_6 product and tails. The rotor assembly is inside an aluminum outer casing that is under vacuum. The casing provides a vacuum enclosure outside the rotor to reduce drag.

B. Centrifuge Drive System

The medium frequency supply system provides the electrical power at the required frequency for the centrifuge drive motors. The system consists of run and run-up solid-state frequency converters, a medium frequency distribution system and 60 Hz electrical supply transformers. The Electrical System is described in Section 3.5.2, Electrical System.

C. Cascade Piping

The arrays of centrifuges that make up a cascade are grouped into blocks; the cascade piping connects these blocks and provides feed, tails, and product flows.

D. Centrifuge Valve Station

The cascades are connected to the UF_6 Feed System, the Product Take-off System, the Tails Take-off System, and the Contingency Dump System. The associated cascade valves and instrumentation are supported on a cascade dedicated valve station. The valve station also provides connection points for the mobile sampling rig and mobile evacuation rigs.

E. Centrifuge Cooling Water Distribution System

The cascade temperature is controlled by a closed loop cooling water system. The cooling water flows through jacketed coils located at the top and bottom of the outer casing. The cascades are housed within thermal panel enclosures to maintain optimum temperature conditions. The Centrifuge Cooling Water Distribution System is described in Section 3.5.5.2, Centrifuge Cooling Water Distribution System.

F. Mobile Cascade Evacuation Rigs

There are three Mobile Cascade Evacuation Rigs. Two Mobile Evacuation Rigs (Table 3.4-22) are used to sustain a low pressure in cascades exposed to UF_6 (contaminated) prior to and during centrifuge run-up or run-down. The third rig is available for drawing a vacuum on a cascade that has not been exposed to UF_6. This "radiological clean" rig is marked to clearly differentiate between the contaminated and radiological clean rigs. The rigs connect to a cascade at the cascade valve station. Each rig consists of a roots vacuum pump, a mixed-bed trap (containing both activated carbon and aluminum oxide), and a rotary vane vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. Rig exhausts are connected to the Pumped Extract GEVS. The activated carbon trap removed small traces of UF_6. The aluminum oxide trap removes HF. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS. A temperature instrument prevents the mixed-bed trap from overheating. The sensor monitors the mixed-bed trap temperature. If the high temperature trip setpoint is reached, the Mobile Cascade Evacuation Rig pumps are deenergized.

G. Mobile Cascade Sampling Rig

A Mobile Sampling Rig (Table 3.4-22) is provided to periodically collect UF_6 samples from a cascade. The rig connects to a cascade at the cascade valve station. The Mobile Cascade Sample Rig consists of a liquid nitrogen dewar, a roots vacuum pump, an activated carbon trap, a rotary vane vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge, and product and tails sample bottles. The rig exhausts to the Pumped Extract GEVS. The activated carbon trap removes small traces of UF_6. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS. A temperature instrument prevents the mixed-bed trap from overheating. The sensor monitors the mixed-bed trap temperature. If the high temperature trip setpoint is reached, an alarm is activated.

3.4.3.3 Design Description

Arrays of gas centrifuges, called cascades, separate gaseous UF_6 feed, with a natural uranium isotopic concentration, into a product stream enriched in the ^{235}U isotope and a tails stream depleted in the ^{235}U isotope.

Should the UF_6 in a cascade need to be rapidly removed to protect the equipment from a process upset or failure, it is automatically accomplished via the Tails Take-off System. Should this system be unavailable at the time, a Contingency Dump System functions as a backup. A centrifuge monitoring system detects rotor failures, i.e., "crashes," and signals the Control Room.

Each centrifuge has an outer casing which functions as a vacuum chamber to reduce friction on the centrifuge rotor, and acts as a barrier for flying parts should a centrifuge fail.

Mobile evacuation rigs are used to evacuate the cascade prior to startup, for maintenance, and shutdown purposes. A mobile cascade sample rig is provided to periodically collect UF_6 samples from a cascade. These rigs are connected at the cascade valve station.

The design bases, codes and specifications used by Urenco in the centrifuge and cascade design provide a large safety margin between normal and accident conditions so that no failures could result in any release of hazardous material. Applicable codes and standards are given in Table 3.4-3, Cascade System Codes and Standards. Operation of hundreds of thousands of centrifuges over many years in Europe have demonstrated the process, equipment, and containment reliability. The gas centrifuges used in the NEF, Urenco's Model TC-12, are designed to operate continuously for many years. The resultant loads from centrifuge failures are restrained by the casing and the floor mounting element (flomel). These components are designed so rotor debris does not penetrate the casing and the flomels do not break away from the floor. The inventory of UF_6 in each centrifuge and in a cascade is low. The UF_6 is contained by the outer casings that are housed within enclosures for thermal stability.

3.4.3.4 Interfaces

The Cascade System interfaces with the following systems and utilities.

A. UF_6 Feed System

B. Product Take-off System

C. Tails Take-off System

D. Contingency Dump System

E. Centrifuge Cooling Water Distribution System

F. Compressed Air System

G. Electrical System

H. Plant Control System.

3.4.3.5 Design and Safety Features

The Cascade System is designed and constructed to provide safe operation for plant personnel as well as the general public. Release of UF_6 to the atmosphere is minimized by:

A. All process piping, valves and vessels that contain UF_6 operate at sub-atmospheric pressure. Initial leaks would be inward to the system. Abnormal pressures caused by such leaks or process upsets are detected by strategically located pressure sensors and indicated by alarms. Appropriate actions are initiated by the operator. At certain levels, the actions begin automatically. Actions to stop UF_6 flow, isolate equipment, or shutdown systems are accomplished to avoid the release of UF_6.

B. If a centrifuge fails, (i.e., "crashes"), it is isolated to prevent contamination from entering other parts of the cascade. Current sensors are provided to detect crashes.

C. If a process upset occurs (pressure or temperature), the cascade is dumped to the Tails Take-off System. If the Tails Take-off System is unavailable, the gasses are evacuated to the Contingency Dump System.

D. The centrifuge outer casing is the primary barrier to the escape of UF_6. The casing encloses the rotor and its component parts and maintains them under vacuum. The outer casing provides confinement of the UF_6 in the centrifuge. It also serves to contain parts or fragments potentially spinning off a centrifuge during a failure. It is reinforced at both ends to contain the heavier rotor end caps and end cap fragments and has design features to prevent end cap debris from impacting non-reinforced areas of the casing. Cascades are designed so that failed centrifuges can be left in place.

E. The floor mounting element (flomel) and the associated bolts for the centrifuges are designed to remain intact after a rotor failure to prevent the centrifuge casing from breaking away and damaging other centrifuges or injuring workers. The flomel consists of a concrete floor mounting element with threaded metal inserts for anchoring the centrifuge foot flange via bolts. The flomel in turn is securely cast in the concrete floor of the Cascade Hall.

3.4.3.6 Operating Limits

The combined capacity of all Cascade Systems is3,000,000 SWU/yr with a maxium product assay limit of 5 $^{w}/_{o}$ ^{235}U. .

3.4.3.7 Instrumentation

The process variables such as pressures, temperatures, valve positions and flowrates are automatically controlled. Deviations from the specified values are detected and indicated via a two or three level alarm signal. Normally at the first alarm, the operator has the ability to manipulate the process to restore it to normal. At the second and sometimes the third alarm, automatic action is taken to provide system protection. For safety, system protection and operability sensors may be single, duplicate (one out of two action) or triplicate (one or two out of three action).

Each cascade is provided with two control systems. Under normal operating conditions one system carries out all of the required process control and protection logic; the second system provides a safety 'envelope' around the control system functionality. The failsafe mode for both systems is Contingency Dump.

If any out-of-limit temperatures, pressures or cooling water temperatures are detected, the cascade is automatically shutdown and UF_6 evacuation to the Tails Take-off System is initiated.

3.4.3.8 Criticality Safety

3.4.3.8.1 Centrifuges and Cascades

Criticality safety of TC-12 centrifuges was initially assessed assuming 6 $^{w}/_{o}$ ^{235}U enrichment without flooding. The only potential for a criticality incident in a centrifuge cascade is by gross uranium accumulation in failed centrifuges. To achieve criticality in a cascade would require an array of failed centrifuges to be completely filled with uranic breakdown (as $UO_2F_2 \cdot 3.5H_2O$). The extreme conditions required to obtain the necessary uranic accumulation for criticality by this mechanism could never credibly occur in practice. Furthermore, it is highly unlikely that: (1) the centrifuges in such an array would fail simultaneously, (2) the failures would lead to inleakage of moist air into the failed centrifuges, (3) all the failed centrifuges would fill up with UF_6 breakdown products, and (4) would have an Hydrogen/Uranium (H/U) ratio that is near optimum. Therefore, the possibility of a criticality incident in a centrifuge cascade can be considered not credible.

To assess criticality safety under flooded conditions, two calculations were performed for arrays of crashed centrifuge bores partially and completely filed with uranic breakdown (as UO_2F_2 $3.5H_2O$) (ETC Calculation Criticality Calculation for Crashed TC-12 Machines in Flood – Partially Filled Bores and ETC Calculation Criticality Calculation for Crashed TC-12 Machines in Flood – Completely Filled Bores). Various water levels up to 60 cm were used to obtain maximum $k_{eff.}$ For the arrays of partially filled centrifuge bores, k_{eff} was determined as a function of fill height to obtain the safe mass that meets the criticality safety criterion of k_{eff} <0.95.

The criticality calculations with MONK8A (SA, 2001) for flooding conclude that the case of partially filled bores is more limiting than that of completely filled bores. The safe mass for the limiting case under flooded conditions remains the same as for the dry conditions (i.e., no flooding) and represents 1,015 kg of UF_6 distributed in a 3x4 array of 12 bores, giving an average content of about 84.6 kg of UF_6 per bore. This quantity far exceeds the UF_6 holdup in an intact machine under normal conditions or the observed amount of uranic material formed due to air in-leakage into a failed machine, which is typically on the order of grams. There is no credible mechanism for such a large accumulation of uranic material in a failed or crashed machine. Furthermore, it is highly unlikely that: (1) the centrifuges in such an array would fail concurrently and the plant would continue to operate, (2) the failures would lead to large in-leakage of moist air or significant moderator intrusion into the failed centrifuges without crashing to stop the enrichment process, (3) all the failed centrifuges would fill significantly with UF_6 breakdown products, and (4) the UO_2F_2/water mixture would have an H/U ratio at the limiting upper value of 7 in a system requiring high vacuum for normal operation. Therefore, the possibility of an inadvertent criticality in a centrifuge cascade remains not credible under flooded conditions.

3.4.3.8.2 UF_6 Product Piping

Product piping in the Separations Building Modules (SBMs) varies in size. Only minimal surface deposition of UF_6 occurs in piping but criticality safety has been assessed for the possibility of localized blockages in pipes with the formation of uranyl fluoride due to air in-leakage.

MONK8A (SA, 2001) calculations were performed for generic arrays of pipe intersections, filled entirely with uranyl fluoride / water mixture at optimum moderation at 6.0 $^{w}/_{o}$ enrichment. The calculation assumed no flooding, as pipe runs are typically above the flood levels especially for the cascade headers which are located above the centrifuges. Spurious reflection with 2.5 cm of water was placed either at the model boundary or at each pipe to determine the more reactive configuration. The optimum H/U ratio varied with pipe size and spurious reflection model. The minimum permitted free space (i.e., edge separation) between intersections was determined to be 580 mm (22.8 in) for 150 mm (5.9 in) nominal pipe165 mm (6.5 in) for 100 mm (3.9 in) nominal pipe, and 70 mm (2.76 in) for 65 mm (2.56 in) nominal pipe; and no spacing restriction applies to piping of nominal diameter 40 mm (1.57 in) or less. If used, product pipes larger than the 150 mm nominal pipe require an explicit nuclear criticality safety analysis.

The above restrictions apply to individual pipe runs with up to 64 intersections or adjacent pipe runs totaling up to 64 intersections. This generic piping arrangement is based on a network of 64 piping nodes in a 4X4X4 cube, where each element of the cube has a vertical pipe and two horizontal pipes all meeting at right angles in the center (picture the meeting of the x, y, and z axis in a three-dimensional Cartesian coordinate system).

Parallel pipe runs containing product material will either fit within the safe-by-design value or be explicitly modeled and analyzed. For example, a safe condition can be demonstrated through analysis for the case where the spacing restriction might not be satisfied, but the piping might have fewer than 64 intersections.

The SBM piping conforms to the above specifications. If not, explicit calculations need to be performed to satisfy the passive Safe-By-Design (SBD) requirements. The affected product piping systems must be designed and demonstrated to meet the subcriticality requirements ($k_{calc} + 3\sigma_{calc} < 0.95$) for normal and credible abnormal conditions. Flooding up to 60 cm needs to be considered only if piping could be subject to the flood conditions in the event of a local intense precipitation.

3.4.3.8.3 Cascade Header Pipework

The pipe intersection criticality calculation described in Section 3.4.3.8.2 is for a generic piping arrangement. This calculation does not bound the configuration of the cascade header pipework because the parallel pipes are closer together than the minimum spacing required for a given pipe size. A separate MONK8A (SA, 2001) calculation was performed to demonstrate criticality safety of the cascade header pipework for the most reactive section of the pipework configuration as a bounding calculation.

The cascade header pipework calculation modeled the pipework inside a cascade hall and included a row of nearby centrifuges for interaction. Interaction with a mobile vacuum cleaner is considered unlikely as the pipes are over 3 m from the ground level. However, for conservatism, the vacuum cleaner filled with wet uranyl fluoride at optimum moderation was included and placed in the most reactive position. The vacuum cleaner was conservatively modeled as a cylinder of 66 cm in length and 20.3 cm in diameter (21.4 L), though any vacuum cleaner approved for use at the facility will be limited to 7 L in volume. Spurious reflection was modeled by wrapping 2.5 cm of water around all pipes and equipment. Flooding consideration is unnecessary because of the elevation of the pipework.

Movement of the pipework due to the effect of a seismic event was taken into account. The pipes can move a maximum of 12 mm in any direction radially from their nominal positions. All of the pipes were therefore modeled at least 24 mm closer to each other and to the centrifuges to simulate the seismic upset condition.

The results of the calculation show that the cascade header pipework is safely subcritical for normal and credible abnormal conditions for enrichment up to 6%. The maximum k_{eff} (k_{calc} + $3\sigma_{calc}$) is less than the limit of 0.95 for the credible worst-case configuration and condition, which considers interaction with fixed plant equipment (centrifuges) and a mobile vessel (vacuum cleaner) as well as movement of the pipework due to a seismic event.

3.4.3.8.4 Cascade Valve Frames

The configuration of the cascade valve frame pipework also deviates from the pipe intersection calculation described in Section 3.4.3.8.2, as some of the parallel pipes could be closer together than the required minimum spacing for a given pipe size. A separate MONK8A (SA, 2001) calculation was performed to demonstrate criticality safety of the cascade valve frame for the most reactive configuration and condition as a bounding calculation.

The calculation modeled the sections of the system which could contain enriched material including the product section of the valve frame at 6% enrichment and the contingency dump feed and tails take-off systems piping at 1.5% enrichment. Interaction with other plant equipment and mobile vessels was taken into account by modeling: (1) a conservative 21.4 L vacuum cleaner in contact with the product pipes, (2) a mobile rig simulated by the bounding product vent vacuum pump/chemical trap set with the middle chemical trap positioned in contact with the valve frame and vacuum cleaner, and (3) a mobile 14 L pump moved for maintenance in transit at 60 cm edge separation from the cascade frame. All of these interacting components were filled with wet uranyl fluoride at 6% enrichment either maximum expected or optimum moderation. Spurious reflection was modeled by wrapping 2.5 cm of water around all pipes and equipment. The cascade valve frame is located on the second floor of the process services corridor and would not be subject to flooding.

The results of the calculation show that the cascade valve frame is safely subcritical for normal and credible abnormal conditions for enrichment up to 6% for the product section, 1.5% for the contingency dump system piping and 1.5% for the remaining piping and valves (feed and tails sections). The maximum k_{eff} (k_{calc} + $3\sigma_{calc}$) is less than the limit of 0.95 for the credible worst-case configuration and condition analyzed.

Movement of the pipework and valves in the cascade valve frame due to a seismic or tornado missile event is inconsequential to criticality, as the reactivity of the system is driven by the interacting components such as the vacuum cleaner and mobile rig. Further, significant movement would result in severe damage to the cascade valve frame which would no longer retain optimally moderated uranyl fluoride or accumulate additional material to cause an inadvertent criticality.

3.4.3.8.5 Mobile Cascade Evacuation and Sampling Rig System

The Mobile Cascade Evacuation and Sampling Rig System consists of the Mobile Evacuation Rigs for cascade evacuation, and the Mobile Sampling Rigs for sampling both product and tails material from an individual cascade. These rigs are connected via the cascade valve frame. The rigs share many common features and components such as chemical traps, vacuum pump, oil adsorption filter and exhaust filter; and are very similar to the product vent vacuum pump/chemical trap set.

A nuclear criticality safety evaluation performed for the Mobile Rigs demonstrates that the criticality safety of the Mobile Rigs is bounded by the case for the product vent vacuum pump/chemical trap set described in Section 3.4.4.8.3. The evaluation considers the clustered arrangement of the components involved and compares the volume available for fissile material accumulation between the Mobile Rigs and bounding product vent vacuum pump/chemical trap set. The k_{eff} for these mobile rigs cannot exceed that of the bounding case for the product vent vacuum pump/chemical trap set.

3.4.4 (See SAR § 12.2.2.3) Product Take-off System

3.4.4.1 Functional Description

The primary function of the Product Take-off System is to provide continuous withdrawal of the enriched gaseous UF_6 product from the centrifuge cascades (REF. Figure 3.4-10, Process Flow Diabram Product Take-Off System). The product is transported via a train of vacuum pumps to chilled 30 in diameter cylinders where the UF_6 is desublimed. A secondary function of this system is to provide a means for venting light gas impurities from the enrichment process.

Under normal operating conditions, the Product Take-Off System produces small intermittent quantities of gaseous effluent from the treatment of light gas impurities in the Product Vent Subsystem. Additional small quantities of intermittent gaseous effluent are produced from purging and evacuating the flexible piping used to connect the product cylinders to the system during cylinder changeout. This effluent from the Product Vent Subsystem is routed to the Pumped Extract GEVS for further treatment. Solid wastes are produced from periodic change-out of chemical and oil traps. There is no liquid effluent directly produced in this system. Vacuum pumps are taken out of service for maintenance and the pump oil is reprocessed in the CRDB and reused.

The Product Take-off System (Ref. Figure 3.3-3, UF_6 Handling Area Equipment Locations) is located in the SBM UF_6 Handling Area and the Process Services Corridor. The Product Take-off System is operated from the Control Room, with the exception of locally controlled vacuum pump, cylinder maintenance, and preparation operations.

3.4.4.2 Major Components

The major Product Take-off System components are listed below.

A. Product Take-off System Main Header

The product take-off system main header connects each cascade to the product pumping trains. Pressure transducers in the header protect the cascades from air ingress or back flow of UF_6.

B. Product Pumping Trains

Each Cascade Hall has three product pumping trains connected in parallel. Two pump trains are on-line while the other is in standby or maintenance. Each train consists of a set of two vacuum pumps connected in series. Manual and automatic valves isolate each pump set. The pump train transports the UF_6 product from each cascade to the Product Low Temperature Take-off Stations.

C. Product Low Temperature Take-off Stations

The Product Low Temperature Take-off Station (LTTS) consists of a composite-wall insulated box. The Product LTTS panels have a non-flammable insulated core, and are vapor sealed to prevent ice build-up within the insulation. The Product LTTS is designed to prevent ice build-up within the box. The Product LTTS totally encloses the cylinder, cylinder support structure, and rails. The front of the Product LTTS has a single door through which the cylinder is inserted and removed. The back of the Product LTTS has an opening through which the cylinder is connected to the UF_6 piping. The cylinder valve and inlet piping are electrically heated. The door frames, access port, rubber collar, and defrost condensate piping are provided with heat tracing to prevent ice build-up.

Each Product LTTS has a chiller unit, which is mounted on the top of the Product LTTS. This unit provides the cold air necessary to decrease the temperature in the box sufficiently to remove the thermal energy from the UF_6 gas and cause it to desublime in the cylinder. The chiller unit has a defrost cycle to remove ice from the cooling coils. This is done with a defrost heater at the coils. Condensate from the chiller is routed to a safe-by-design drip pan to allow the water to evaporate.

The valves used to route the product to the appropriate Product LTTS, or for venting and purging, are mounted in a valve frame near each Product LTTS.

Each Product LTTS is provided with a weighing system, which incorporates a weigh frame, four load cells, and associated weighing instrumentation. The weigh system provides continuous measurement of the mass of UF_6 accumulating in the product cylinder.

D. Product Vent Subsystem

The Product Vent Subsystem consists of a product vent transfer header, two horizontal UF_6 cold traps, two heater/chiller units, two automatic control valves, and two vacuum pump/chemical trap sets. These components are discussed below.

1. UF_6 Cold Traps with Heater/Chiller Units.

Each UF_6 cold trap consists of an insulated horizontal tube with internal baffles and a dedicated heater/chiller unit. Each heater/chiller unit contains approximately 70 L (19 gal) of silicon oil, as the heat exchange media, which circulates around each cold trap. These Product Vent Subsystem heater/chiller units are separated by over 30 m (100 ft) from other heater/chiller units in similar subsystems. The UF_6 cold trap is chilled to cause UF_6 in the vent gases to desublime. It is heated to sublime the trapped UF_6 for transfer back to a product cylinder. Each end of the UF_6 cold trap is heat traced to prevent the UF_6 from desubliming and blocking the inlet and outlet. The heat tracing also prevents ice from building up on the outside of the UF_6 cold trap and affecting the weighing system.

Each UF_6 cold trap is provided with a weighing system, which incorporates a weigh frame, four load cells, and associated weighing instrumentation. The weigh system provides continuous measurement of the mass of UF_6 accumulating in the UF_6 cold trap and indicates when it is full to prevent overfilling.

2. Vacuum Pump/Chemical Trap Sets.

The vacuum pump/chemical trap set consists of a carbon trap, two aluminum oxide traps, and an insulated vacuum pump with internal nitrogen purge and an aluminum oxide oil traps on the pump suction and mechanical oil trap (exhaust filter) on the pump discharge. The exhaust from the vacuum pump goes to the Pumped Extract GEVS.

The activated carbon removes small traces of UF_6. The aluminum oxide removes HF. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

E. Assay Sampling System

Product Assay Sample piping installed on the product header after the product pumping trains allows a product assay sample to be collected in a sample bottle. Because the output from all centrifuges in a cascade hall eventually go to a single product (or tails) header, an "assay" is the output of all the cascades in that cascade hall. For example, SBM-1001 Assay 1001 is the output from all of the cascades in SBM-1001 Cascade Hall 1. The sample system is comprised of automatic and manual valves, nitrogen purging, and an evacuation pump and trap (Assay Sampling Rig) set similar to the one described above. However, this set contains one mixed-bed trap containing both activated carbon and aluminum oxide. This pump/trap set also contains a flow restriction device (IROFSC21) on the suction side of the pump. A temperature instrument prevents the mixed-bed trap from overheating. The sensor monitors the mixed-bed trap temperature. If the high temperature trip setpoint is reached, an alarm is activated.

F. On-line Mass Spectrometer System

The On-line Mass Spectrometer System piping connection installed on the product header, after the product pumping trains, allows a small gas sample to be fed to an on-line mass spectrometer. The on-line mass spectrometer analysis results allow any required adjustments to be made to the cascades.

G. Mobile Maintenance Rig

The Mobile Maintenance Rig is provided to evacuate pipework, plant equipment, and UF_6. The mobile maintenance rig can connect to a cascade at the cascade valve station or other locations as necessary to support maintenance activity where evacuation of the pipework, plant equipment is required. The Mobile Maintenance Rig can be used in conjunction with other mobile rigs such as the Helium Leak Test Cart. Each Mobile Maintenance Rig consists of three assemblies. The cold trap assembly consists of K300 cold trap, liquid nitrogen dewar, associated valves and piping. The chemical trap assembly consists of one mixed-bed trap (containing both activated carbon and aluminum oxide), pressure instruments, chemical trap temperature instrument, piping and valves. The pump assembly contains a roots vacuum pump and a rotary vane vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. The assemblies are connected together using flexible piping. The Mobile Maintenance Rig's exhaust is connected to the Pumped Extract GEVS.

During use, the evacuated contents from the pipework / equipment are initially pumped either through a cold trap when UF_6 is expected or into the chemical trap assembly bypassing the cold trap when minimal qualities of UF_6 are expected. The activated carbon removes small traces of UF_6. The aluminum oxide trap removes HF. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

The chemical trap temperature instrument prevents the mixed-bed trap from overheating. The sensor monitors the mixed-bed trap temperature. If the high temperature trip setpoint is reached, an alarm is activated and the rig's pumps are tripped off.

Although the Mobile Maintenance Rig is described here in the product take-off system section, it should be noted that it is utilized throughout the UF_6 process system, e.g., feed, cascade, tails, product blending, contingency dump systems, etc., and UF_6 containing systems in the CRDB. For discussion of the criticality evaluation for this rig see Section 3.4.4.8.7.

3.4.4.3 Design Description

The design bases and specifications are given in Table 3.4-4, Product Take-off System Design Basis. Applicable Codes and Standards are given in Table 3.4-5, Product Take-off System Codes and Standards.

The Product Take-off System is dedicated to an individual Cascade Hall. The system is designed to continuously remove the enriched UF_6 product from the cascades under all operating conditions.

The entire Product Take-off system operates at subatmospheric pressure. In the event of a containment failure (e.g., pipe leak), releases of UO_2F_2 and HF is greatly minimized because air would migrate into the system rather that UF_6 pouring out of the system. This important safety feature greatly limits the likelihood of exposures.

There are five Product LTTS for each Cascade Hall. Of these five, two are on-line during normal operation. Two of the remaining three Product LTTSs are in standby auto. One of these Product LTTS is automatically switched to on-line when one of the two on-line cylinders is full. The fifth station is in standby (cylinder inside station but not on automatic), off-line, preparation (cylinder being removed or inserted), or maintenance mode.

Gaseous UF_6 product from the cascades flows from each centrifuge cascade, through the product main header, to the pumping trains. Typical main header pressures are on the order of a few mbar.

From the product pumping trains the UF_6 flows to the product cylinders housed in the Product LTTSs. The transfer header pressure is limited to 80 mbar (32.1 in. H_2O) to prevent UF_6 desublimation at ambient temperatures. Building ambient temperature is maintained above 18°C (64.4°F) so that heat tracing of the UF_6 transfer piping is not required.

Light gas impurities normally exit the centrifuges with the product rather than with the tails. To remove these impurities, the product cylinders are vented using a standby cylinder and the Product Vent Subsystem.

During production it is necessary to measure the concentration of the product or tails being produced. The operator can collect a sample for manual analysis using the Assay Sampling System or automatically measure the concentration using the On-line Mass Spectrometer System.

Materials of construction and fabrication specifications for the equipment and piping used in the Product Take-off System are compatible with UF_6 at the operating conditions and have been proven by over 30 years of use in existing Urenco European enrichment plants.

3.4.4.4 Interfaces

The Product Take-off System interfaces with the following systems and utilities.

A. Cascade System
B. Pumped Extract GEVS
C. Nitrogen System
D. Plant Control System
E. Compressed Air System
F. Electrical System
G. Hoisting and Transportation Equipment.

3.4.4.5 Design and Safety Features

The Product Take-off System is designed and constructed to provide safe operation for plant personnel as well as the general public. Principal design features are as follows:

A. All piping, vessels, and pumps in the Product Take-off System operate at sub-atmospheric UF_6 pressures.

B. Piping is all welded construction and process valves are bellows sealed.

C. Before carrying out any disconnections or connections of equipment, the piping is evacuated and purged with nitrogen. Flexible exhaust hoses connected to the Pumped Extract GEVS via a temporary local extract cross-connection, during initial plant operations, remove any releases from the work area.

D. Before discharge to the Pumped Extract GEVS, all gases flow across activated carbon and aluminum oxide to remove any traces of UF_6 and HF via the product vent vacuum pump/chemical trap set.

E. Temperature in each Product LTTS is monitored and controlled.

F. Product cylinder overfill is prevented by two weight trips. The first is at the desired net weight of UF_6 and the second is at the gross weight of the cylinder with UF_6 contents. Only the first trip is operator adjustable.

G. Removal of a connected product cylinder from the Product LTTS is prevented by an interlock system. Unless the flexible hose on the cylinder valve has been removed and locked in its "holster," a physical barrier prevents the cylinder transporter drawbridge from docking with station rails, thereby preventing cylinder removal.

H. Hydrocarbon lubricants are not used in any pumps. All pumps are lubricated with perfluorinated polyether (PFPE) oil, a fully fluorinated synthetic oil.

I. Temperature and weight in the product vent vacuum pump/chemical trap set carbon trap are monitored and a trip on weight and a trip on temperature stops the product vent vacuum pump.

J. Mechanical interlocking systems are provided in all solid feed and low temperature stations to prevent the operation of the stations with an incorrect cylinder type loaded. The system prevents the use of identified for product take-off from being used in either a solid feed station or feed purification station.

3.4.4.6 Operating Limits

The Product Take-off System has the capacity to remove the UF_6 product on a continuous basis from the cascades at all rates under normal operating conditions.

3.4.4.7 Instrumentation

The process variables, such as pressure, temperature, and valve position, are automatically controlled. Deviations from the specified values are detected and indicated by a two level alarm system. An alarm, the operator has the ability to manipulate the process to restore it to normal. A second alarm, automatic action is taken to provide system protection. For safety, system protection, and operability, sensors may be duplicated (one out of two action) or triplicated (one out of three action). Action is initiated if any one out of two or three sensors reach alarm levels.

A. Main Header

The product main header pressure is monitored with three pressure sensors. A high alarm is set to give operator warning of high pressure. A high high (HH) alarm signals the Cascade System that the product main header is not available.

B. Product Pumping Trains

Each product pumping train inlet pressure is monitored. Normal operating pressure is <2 mbar (<0.8 in H_2O). A high (H) alarm (H) warns the operator of high pressure. A high high (HH) alarm automatically closes the inlet and outlet valves and trips the pump train off-line to protect against air leakage into the cascades.

The outlet pressure of each product pumping train is monitored. Normal operating pressure is <55 mbar (<22.1 in H_2O). An alarm provides the operator warning of high pressure. A second alarm automatically closes the inlet and outlet valves and trips the pump train off-line.

C. Product Low Temperature Take-off Stations

Each product cylinder inlet pressure is monitored. Normal operating pressure is <50 mbar (<20.1 in H_2O). An alarm is set to automatically initiate the timed cylinder venting sequence. A second alarm warns of high pressure. A third alarm closes the Product LTTS inlet valve and trips the Product LTTS off-line.

For weight control, each Product LTTS has a weighing system consisting of four load cells and a transmitter to monitor the contents of the product cylinder. A weight of less than 800 kg (1,764 lb) indicates no cylinder present in the Product LTTS. The first alarm, set at the net allowable weight of UF_6 in the product cylinder, promotes a standby Product LTTS to on-line and closes the Product LTTS inlet valve to prevent overfilling. A second alarm, set at the gross allowable weight of the product cylinder filled with UF_6, also closes the inlet valve and trips the Product LTTS off-line. The output of the weighing system also allows cylinder weight to be verified to be within specified trending limits.

For temperature control and protection from high temperatures, the Product LTTS has a stand-alone control and protection system. The total system consists of three sensors. For main Product LTTS temperature control, one sensor is mounted in the air return to the chiller unit and monitors the circulating air temperature. This sensor and local control maintains the Product LTTS temperature . In addition to controlling the Product LTTS temperature, one output is monitored by the Plant Control System and warns when the air temperature rises. This would indicate a chiller failure or that the defrost heater is not functioning properly. When the defrost heater is on, the circulating air fan is off to minimize the increase in Product LTTS air temperature.

In addition to the closed loop control system previously described, there are two independent and diverse temperature protection instruments. These provide extra safety margin to protect against increases in temperature that may occur if the heater control did not operate properly. The first instrument is a fail-safe hardwire RTD and the second instrument is a fail-safe thermocouple. Both of these instruments measure the temperature of air inside the LTTS. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above their set point. If heater trip occurs from these two instruments, the Product LTTS is automatically taken off-line and put into a standby mode.Both instruments are set to trip at set points well below the calculated set point required to ensure cylinder integrity.

To prevent UF_6 desublimation in the product cylinder valve, the valve and inlet piping are electrically heated.

D. Product Vent Subsystem

1. UF_6 Cold Traps

The vent header pressure, between the Product LTTS and the UF_6 cold traps, is monitored. During the vent sequence the normal pressure is at or below 50 mbar (20.1 in. H_2O). During the gas back sequence, when UF_6 is sublimed in the UF_6 cold trap for transfer back to a product cylinder, the header pressure is at the UF_6 vapor pressure. A gas back first alarm warns of high pressure. A second alarm closes the Product LTTS vent valve to prevent flow back into the Product Take-off System.

During venting operation, the product vent UF_6 cold trap outlet pressure is monitored. A low alarm set at 20 mbar (8. in. H_2O) indicates the UF_6 cold trap is empty in gas back mode. A second low alarm level closes UF_6 cold trap outlet valve automatically to prevent UF_6 flow to vacuum pump. A first high alarm warns of high pressure. A second high alarm switches the heater/chiller unit off, trips the UF_6 cold trap off-line, and closes the outlet valve.

A pressure sensor and control valve between each UF_6 cold trap and its vacuum pump/chemical trap set restricts the flow of light gases through the UF_6 cold trap to ensure all UF_6 desublimes and does not reach the carbon trap. The line pressure into the vacuum pump/chemical trap set is controlled.

A weighing system monitors the contents of the UF_6 cold trap. An alarm warns that the UF_6 cold trap is approaching capacity. A second alarm closes the UF_6 cold trap inlet and outlet valves and the UF_6 cold trap is switched off-line.

The temperature of the UF_6 cold trap is controlled during cooling to desublime any UF_6 and for heating during sublimation to empty the UF_6 cold trap of collected UF_6 (gas back). A low alarm warns of a chiller unit fault. A high alarm closes the UF_6 cold trap outlet valve and a second high alarm warns of high temperature during gasback. The final high alarm trips the unit off-line to avoid desublimation of UF_6 in the header.

2. Vacuum Pump/Chemical Trap Sets.

The carbon trap has a temperature instrument that prevents overheating. If the high temperature setpoint is reached, a signal is sent to the PCS to warn the operator of the abnormal condition.

The second (downstream) activated aluminum oxide (Al_2O_3) trap on the vacuum pump/chemical trap set is equipped with a weigh system. The weigh system on the aluminum oxide trap only displays a weight locally. There is no control function on this weight indicator.

Increase in weight is an indication that the first Al_2O_3 trap is saturated. The traps are replaced based on the accumulated weight.

E. Assay Sampling Subsystem.

The assay sampling header pressure is monitored to prevent air entering the Product Take-off System and Tails Take-off System. A high level alarm closes the assay sampling inlet valves. The sample inlet valves (product and tails) and the sample evacuation valve are interlocked, allowing only one of the valves to be open at any one time. Both sample inlet valve open cycles are timed.

3.4.4.8 Criticality Safety

3.4.4.8.1 Product Cylinders

The product enrichment within a 30B product cylinder is limited to 5.0 $^{w}/_{o}$ ^{235}U by the plant design, configuration and operating features. The UF_6 content is limited to no more than the 30B cylinder fill limit by the plant design and operating features. The moderation within the cylinder is controlled by a series of plant operating features. These features include, among others, checks that the cylinder is clean and empty prior to the commencement of fill. Also, the moderator (H_2O, HF) entering the cylinder is monitored during the time the cylinder is connected to the plant UF_6 systems.

The criticality analysis with MONK8a (SA, 2001) models effectively infinite two-dimensional arrays of full 30B product cylinders. Inside each cylinder a spherical region of 6% enriched UO_2F_2/water mixture having a radius at optimum H/U ratio is located at the end of the cylinder. The remainder of the interior of the cylinder is assumed to be filled with 6.0% ^{235}U enriched low density UF_6 with no moderator (water). Cylinders in the arrays are placed with the valve and base ends alternately in contact, so that the moderated region in a given cylinder is in the closest possible proximity to the moderated region in an adjacent cylinder. All cylinders are considered to be lying on a concrete pad one meter thick. Sphere moderation is varied to obtain the optimum H/U ratio. Worst-case external reflection/moderation conditions are found by varying the density of the interstitial water between cylinders to simulate foam, mist, frost, or snow. The calculation also assumes one transient 30Bcylinder above (touching) the array to simulate movement in/out/over the array. Criticality safety of Type 30B product cylinders depends on the control of moderator content.

The criticality analysis for flooding up to 60 cm of water shows that a base array of 30B product cylinders with a transient 30B cylinder directly on top remains safe (i.e., $k_{eff} < 0.95$) under all conditions analyzed.

For the 30B cylinder, the condition that met the upper safety limit had an H/U ratio of 10.5 with an interstitial water density of 0.10 g/cm3 (6.24 lb/ft3). Thus, the maximum safe mass of hydrogen in each type product 30B cylinder in an array was determined to be 0.98 kg (2.16 lb) present in the form of 8.8 kg (19.4 lb) of water.

3.4.4.8.2 UF_6 Cold Traps

Although the cold traps have a large internal volume they are individually safe by shape, the trap body having an internal diameter of 20.3 cm (8.0 in). This compares with the safe diameter of 22.4 cm (8.82 in) for 6.0 $^{w}/_{o}$ enrichment. Individual cold traps are thus safe in isolation for any uranyl fluoride/water mixture. In practice the maximum H/U atom ratio in the cold traps will be 7; however, a sensitivity study is performed to determine the optimum H/U ratio, providing an additional margin of safety.

The cold trap and the standby cold trap are separated from each other by center-to-center separation of 110 cm (43.3 in). Calculations were performed on the isolated pair of completely filled cold traps and were found to be substantially subcritical. The calculations assumed an enrichment of 6.0 $^{w}/_{o}$, an optimum H/U ratio of 14 and 2.5 cm (0.984 in) water reflection placed around the outer surfaces of the trap to simulate spurious reflection.

There are no restrictions on movement of mobile vessels in regard to the cold traps.

For interaction, MONK8A (SA, 2001) bounding calculations were performed in which both cold traps are brought together and a 7 L vacuum cleaner is in contact with, and placed below, both of the cold traps, and another vessel (a 14 L (3.7 gal) product vent vacuum pump) is at 60 cm (23.6 in) edge spacing from one of the cold traps. The cold traps, vacuum cleaner and mobile pump were all filled with uranyl fluoride/water mixture at 6% enrichment with optimum moderation (H/U=12). Spurious reflection with 2.5 cm of water for each component was modeled. Flooding up to 60 cm of water was included. The resulting k_{eff} is less than the limit of 0.95, meeting the subcriticality safety requirement

The cold traps have therefore been determined to be safe both as a pair in isolation and touching while interacting with other fixed plant or vessels in movement for ^{235}U enrichments up to 6.0 $^{w}/_{o}$.

3.4.4.8.3 Vacuum Pump / Chemical Trap Sets

The components of the Product Vent Subsystem are individually safe-by-design per Tables 3.7-7. The entire Subsystem is safe by design by physical arrangement as demonstrated by MONK8A (SA, 2001) calculations. The MONK8A model included the following process equipment: a carbon chemical trap, two alumina oxide chemical traps , oil adsorption filter, exhaust filter, and rotary vane pump. Transient components include a 7L vacuum cleaner, and a mobile pump or pump set (18 L mobile volume or the Leybold WS1001/251 roots pump set).

The process equipment was filled entirely with uranyl fluoride/water at an enrichment of 6.0 $^{w}/_{o}$ and worst credible H/U ratio of 7 for process conditions. The transient components were modeled with an optimized H/U ratio of 12. The internal structure or fill material was not credited within any components. This model maximized the mass of fissile material within the components and provides added conservatism.

The components were arranged in a configuration to represent seismic upset conditions or impacts from missiles (tornado or construction). The chemical traps were placed as close as physically possible and the remaining components were clustered together. This arrangement maximized the effects of neutron interaction between the components. Neutron interaction between uranium bearing transient components was considered by modeling a 7 L vacuum cleaner in contact with the chemical traps and either a single 18 L volume or a product Roots pump set (Leybold WS1001/251 pumps) in contact with the vacuum cleaner. The standby product vent subsystem was included in the model. Spurious reflection of 2.5 cm water around each component was modeled. Flooding to 60 cm was included in the model to represent extreme conditions.

The vacuum pump/chemical trap sets have been shown to be safe (i.e., $k_{eff} < 0.95$) under normal and credible abnormal conditions for enrichments up to 6.0 $^{w}/_{o}$. The vacuum cleaner is limited to 7 L. It has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly. Transient components allowed within the 60 cm spacing are limited to a volume of 18 L or the product Roots pump set (Leybold WS1001/251). Movement of components due to seismic, tornado missile and onsite construction events would not lead to an inadvertent criticality.

It should be noted that the above MONK8A (SA, 2001) model represents extreme accident conditions in terms of uranium accumulation and moderator ingress. It should also be noted that the simple MONK8A (SA, 2001) model used for the vacuum pump in all of the calculations is conservative. Since the real shape of the internal free volume is far from optimum, an explicit model of the pump is expected to result in a significant reduction in k_{eff}.

3.4.4.8.4 Product Pumping Train UF_6 Pumps

The pump combination unit consists of two Leybold pumps, models WS1001 series and WS251 series, positioned in a fixed frame. The WS251 series has a nominal volume of 6.6 L (1.75 gal). The WS1001 series pump has a nominal volume of 16.6 L (4.4 gal).MONK8A (SA, 2001) calculations were performed to show the criticality safety of the Leybold WS1001/WS251 product roots pump combination at 6% enrichment. From this analysis, the pump combination in isolation meets the subcritical acceptance criteria.

To simulate the product pumping trains, the Roots pumps were modeled as equiaxed cylinders (equal length and diameter) with volumes slightly larger than the maximum theoretical free volumes of the largest pump. Tolerances were taken into account, as was the 0.4 cm thickness of the iron casing. The WS1001 pump was rounded up to a volume of 17.6 litres and the WS251 was modeled at the same volume. Spurious reflection due to walls, personnel, etc. was taken into account by applying 2.5 cm of water reflection to all vessels in the model.

The analysis bounds interaction with mobile vessels, mobile rigs and the effect of a seismic or tornado missile event. Multiple pump sets were modeled in a conservative configuration by an infinite one-dimensional array of pump sets with a 7 L vacuum cleaner inserted between each consecutive pair. This configuration bounds a linear array of pump sets, as the inserted vacuum cleaner is a significant contributor to the system reactivity. For this configuration, it is unnecessary to include flood water as the product pumping trains are located on the second floor of the process services corridor, and flooding due to local intense precipitation is a separate external event. The resulting k_{eff} is less than 0.95, confirming the modeled scenario meets the subcritial acceptance criteria for a seismic or tornado event. All of the components in the model were filled with wet uranyl fluoride at 6% enrichment and optimum moderation. Spurious reflection was taken into account by modeling 2.5 cm of water around the vacuum cleaner and mobile pumps. The effect of flooding up to a water depth of 60 cm was added for conservatism, despite that the product pumps are located on the second floor of the process services corridor which could not be subject to flooding.

The combination of the pump set and interacting units results in $k_{eff} <0.95$. It should be noted that the pumps are individually safe by volume as the safe volume for 6% enriched uranyl fluoride is 19.3 liters.

Note that the movement of vessels considered above is considered to be part of normal operating conditions. The abnormal operating condition pertaining to the vessels concerns the assumption that all the vessels are completely filled with uranic breakdown at optimum moderation. This would be extremely unlikely for a single vessel in the array, and even more unlikely for more than one vessel.

It can be concluded that:

- An array of pump units is safe at any spacing. No restriction is placed on the moderator content of the pump units.
- There is no separation required between the Pumping Trains and any other mobile rig or mobile vessel. No restriction is placed on the moderator content of any of the vessels.

3.4.4.8.5 Process Gas Pipework

During normal operations, the Process Gas Pipework contains gaseous UF_6. The gaseous UF_6 stream flows out of the cascade and into the Process Gas Pipework. Through the Process Gas Pipework, the flow passes via the product and tails Roots pumps into the product and tails take-off cylinders in the UF_6 Handling Area.

The pipe intersection criticality calculation described in Section 3.4.3.8.2 is for a generic piping arrangement. This calculation does not bound the configuration of the process gas piping in the Process Services Corridor because the parallel pipes are closer together than the minimum spacing required for a given pipe size. A separate MONK8A (SA, 2001) analysis was performed to demonstrate criticality safety of the Process Gas Pipework for the most reactive section of the pipework configuration as a bounding calculation.

To simulate abnormal operating conditions, calculations were performed in which the Process Gas Pipework was filled entirely with wet uranyl fluoride at optimum moderation. The enrichment used for each pipe was 1.5% for pipes that could contain dump material, and 6% for product and feed pipes to bound multiple piping configurations. Spurious reflection was modeled by 2.5 cm of water around each pipe.

The calculations included the gas pipework in the following areas: Process Services Corridor (PSC), Assay Sampling Station at the end of the PSC, Product Valve Stations in the UF_6 Handling Area, and Tails Valve Stations in the UF_6 Handling Area. Based on the MONK8A calculations, the pipework in the PSC represents the most reactive configuration. In all cases, k_{eff} is less than the limit of 0.95.

3.4.4.8.6 Assay Sampling Rig

The Assay Sampling Vacuum Pump and Trap set (referred to as the Assay Sampling Rig) consists of manual and automatic isolation valves, a mixed bed chemical trap, a rotary vane vacuum pump, an Al_2O_3 oil adsorption filter and an exhaust filter. Each individual component is safe-by-design by physical size (diameter or volume). The Rig is very similar to the product vent vacuum pump/chemical trap set. The Rig as a whole is safe-by-design by physical arrangement as demonstrated in a nuclear criticality safety evaluation through comparison to a bounding calculation performed for the product vent vacuum pump/chemical trap set described in Section 3.4.4.8.3.

3.4.4.8.7 Mobile Maintenance Rig

The Mobile Maintenance Rig used consists of a K300 cold trap assembly, a chemical trap assembly, and a pump assembly containing a WSU 251 roots pump, a rotary vane pump, an Al_2O_3 oil filter and an exhaust filter. The Mobile Maintenance Rig is used to evacuate pipework and equipment that has been exposed to UF_6 and HF prior to maintenance. The evacuated contents are pumped through a cold trap and chemical traps for removal on any UF_6 and HF and exhaust to the Gaseous Effluent Ventilation System.

The items on the Mobile Maintenance Rig are safe-by-design individually. The Mobile Maintenance Rig as a whole is safe-by design by physical arrangement as demonstrated in a nuclear criticality safety evaluation through comparison to a bounding calculation performed for the product vent vacuum pump/chemical trap set described in Section 3.4.4.8.3.

3.4.4.8.8 (See SAR § 12.2.1.1.5) Mobile Pressure Transducer Calibration Rig

The mobile Pressure Transducer Calibration Rig consists of manual and automatic valves, a number of digital pressure transducers, a pirani-type pressure measurement device, a mixed-bed chemical trap, two rotary vane vacuum pumps, and a turbo-molecular vacuum pump. The Calibration Rig allows for the calibration of pressure transducers located throughout the UF_6 process systems to monitor process pressures. The items on the Calibration Rig are safe-by-design individually. The Calibration Rig as a whole is safe-by-design by physical arrangement as demonstrated in a nuclear criticality safety evaluation through comparison to a bounding calculation performed for the product vent vacuum pump/chemical trap set described in Section 3.4.4.8.3.

3.4.4.8.9 On-Line Mass Spectrometer

The Online Mass Spectrometer consists of manual and automatic isolation valves, a vacuum chamber, cold traps, manual sampling manifolds, automatic sampling batch chambers, quadrupole mass spectrometer, an ion vacuum pump, a rotary vane vacuum pump, and a diffusion vacuum pump. The Mass Spectrometer Room on the second floor of the SBMs contains one Online Mass Spectrometer, sufficient for sampling SBM Assay 1001 and 1002.

A nuclear criticality safety evaluation concludes that the Product Vent Pump / Chemical Trap Set (Section 3.4.4.8.3) analysis and the Product Roots Pumps analysis (Section 3.4.4.8.4) envelope the configuration and conditions for the Mass Spectrometer and that the k_{eff} of the Mass Spectrometer could not exceed that of the cases described. Therefore, the Mass Spectrometer is safe-by-design, meeting the subcriticality requirements.

3.4.4.8.10 Helium Leak Test Cart

The Helium Leak Test Cart is described in Section 3.4.2.2.F A criticality event is not credible for the Helium Leak Test Cart due to the sequence of many unlikely human errors that are required to introduce enriched UF_6 into the Helium Leak Test Cart system.

3.4.5 (See SAR § 12.2.2.4) Tails Take-off System

3.4.5.1 Functional Description

The primary function of the Tails Take-off System is to provide continuous withdrawal of the gaseous UF_6 tails from the centrifuge cascades (Ref. Figure 3.4-11, Process Flow Diagram Tails Take-off System). The tails are transported via a train of vacuum pumps to 48-in diameter cylinders where the UF_6 gas is desublimed. A secondary function of this system is to provide a means for evacuating centrifuge cascades under abnormal operating conditions. Most of the light gases from the separation process are discharged into the product stream, so venting of the tails take-off system is seldom necessary.

Small, intermittent quantities of gaseous effluent are produced from purging and venting the flexible piping used to connect the UBCs (ie., 48Y Tails) to the system during cylinder changeout. This effluent is treated by the Tails Evacuation Pump/Chemical Trap Set to remove UF_6 or HF before being routed to the Pumped Extract GEVS for further treatment. Solid wastes are produced from periodic change-out of chemical and oil traps. There is no liquid effluent directly produced in this system. Vacuum pumps are taken out of service for maintenance and the pump oil is reprocessed in the CRDB and reused.

The Tails Take-off System is located in the UF_6 Handling Area and Process Services Corridor of the SBM (Ref. Figure 3.3-3 UF_6 Handling Area, Equipment Locations). The equipment is operated from the Control Room with the exception of maintenance and preparation activities, which are controlled locally.

3.4.5.2 Major Components

The Tails Take-off System major components are:

A. Primary Header

The tails primary header connects each cascade to the Tails Pumping Trains. Pressure transducers in the header protect the cascades from air ingress.

B. Tails Pumping Trains

Each cascade has two dedicated Tails Pumping Trains connected in parallel. One pump train is on-line while the other is in standby. Each train has one set of pumps andeach set consists of two vacuum pumps in series mounted on a common frame. Manual and automatic valves isolate each pump set.

C. Secondary Header

Tails Pumping Trains discharge into the secondary header. The secondary header connects with the Tails Low Temperature Take-off Stations.

D. Tails Low Temperature Take-off Stations (LTTS)

The Tails LTTS consists of a composite-wall insulated box. The Tails LTTS panels have a non-flammable insulated core, and are vapor sealed to prevent ice build-up within the insulation. The Tails LTTS is designed to prevent ice build-up within the Tails LTTS. The Tails LTTS totally encloses the cylinder, cylinder support structure, and rails. The front of the Tails LTTS has a single door through which the cylinder is inserted and removed. The back of the Tails LTTS has an opening through which the cylinder is connected to the UF_6 piping. The cylinderet piping are electrically heated. The door frames, access port, rubber collar, and defrost condensate piping are provided with heat tracing to prevent ice build-up.

Each Tails LTTS has a chiller unit, which is mounted on the top of the Tails LTTS. This unit provides the cold air necessary to decrease the temperature in the box sufficiently to remove the thermal energy from the UF_6 gas and cause it to desublime in the cylinder. The chiller unit has a defrost cycle to remove ice from the cooling coils. This is done with a defrost heater at the coils.

The valves between the secondary header and the Tails LTTS are mounted in separate frames that are not attached to the Tails LTTS; however, they are in close proximity.

Each Tails LTTS is provided with a weighing system which incorporates a weigh frame, four load cells, and associated weighing instrumentation. The weigh system provides continuous measurement of the mass of UF_6 accumulating in the 48Y UBC.

E. Tails Evacuation Pump/Chemical Trap Set

The Tails Evacuation Pump/Chemical Trap Set consists of a mixed bed (activated carbon an aluminum oxide (Al_2O_3)) trap, and an insulated vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. A flow restrictor (IROFSC21) is located on the suction of the pump after the aluminum oxide oil trap. The exhaust from the vacuum pump goes to the Pumped Extract GEVS.

The activated carbon in the mixed bed trap removes small traces of UF_6 and the aluminum oxide removes HF. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

F. Assay Sampling Subsystem

Piping is installed in the secondary header for sampling. The tails assay sample is taken into sample bottles at this point. The sample system is comprised of automatic and manual valves, nitrogen purging, and an evacuation pump and trap set (Assay Sampling Rig) similar to the one described above. However, this set contains one mixed-bed trap containing both activated carbon and aluminum oxide. This pump/trap set also contains a flow restriction device (IROFSC21) on the suction side of the pump.

G. On-line Mass Spectrometer System

Piping is installed in the secondary header to allow a small gas sample to be fed to an on-line mass spectrometer. The results of the mass spectrometer analysis are used to make process adjustments to the cascades.

3.4.5.3 Design Description

The design bases and specifications are given in Table 3.4-6, Tails Take-off System Design Basis. Applicable Codes and Standards are given in Table 3.4-7, Tails Take-off System Codes and Standards.

The Tails Take-off System is dedicated to an individual Cascade Hall. The system is designed to continuously remove depleted UF_6 (tails) from the cascades under all operating conditions. The entire Tails Take-off System operates at subatmospheric pressure. In the event of a confinement barrier failure (e.g., pipe leak), releases of UO_2F_2 and HF is greatly minimized because air would migrate into the system rather than UF_6 exiting the system. This important safety feature greatly limits the likelihood of worker and public exposures.

There are eleven Tails LTTSs for each Cascade Hall. Of these, seven are on-line during normal operation. These seven are adequate for normal operations as well as peak flows generated during a cascade trip. One Tails LTTS is in standby auto. This Tails LTTS is automatically switched to on-line when one of the seven on-line cylinders is full. The remaining Tails LTTS are in either standby manual (cylinder inside station but not on automatic), off-line, preparation (cylinder being removed or inserted), or maintenance mode.

Gaseous UF_6 tails from the cascades flows from each centrifuge cascade, through the primary header, to the tails pumping trains. Typical primary header pressures are of the order of a few mbar (in. H_2O).

From the tails pumping trains the UF_6 flows through the secondary header to the UBCs housed in the Tails LTTSs. The secondary header pressure is limited to prevent UF_6 desublimation at ambient temperatures. Building ambient temperature is maintained so that heat tracing of the UF_6 piping is not required.

All components of the Tails Take-off System operate at subatmospheric pressure. Release of UF_6 and/or HF is unlikely because leakage, if it were to occur, would be inward to the system.

Materials of construction and fabrication specifications for the equipment and piping used in the Tails Take-off System are compatible with UF_6 at the operating conditions and have been proven by over 30 years of use in existing Urenco European enrichment plants.

3.4.5.4 Interfaces

The Tails Take-off System interfaces with the following systems and utilities:

A. Cascade System
B. Plant Control System
C. Nitrogen System
D. Compressed Air System
E. Pumped Extract GEVS
F. Electrical System
G. Hoisting and Transportation Equipment.
H. Contingency Dump

3.4.5.5 Design and Safety Features

The Tails Take-off system is designed and constructed to provide safe operation for plant personnel as well as the general public. Principal design features are as follows.

A. All piping, vessels, and pumps in the Tails Take-off System operate at sub-atmospheric UF_6 pressures.

B. Piping is all welded construction and process valves are bellows sealed.

C. Before carrying out any disconnections or connections of equipment, the piping is evacuated and purged with nitrogen. Flexible exhaust hoses connected to the Pumped Extract GEVS via a temporary local extract cross-connection, during initial plant operations, remove any releases from the work area.

D. Before discharge to the Pumped Extract GEVS, all gases flow across activated carbon and aluminum oxide to remove any traces of UF_6 and HF via the Tails Evacuation Pump/Chemical Trap Set.

E. Temperature in each Tails LTTS is monitored and controlled.

F. Cylinder overfill is prevented by two weight trips. A trip is at the desired net weight of UF_6 and a second trip is at the gross weight of the cylinder with UF_6 contents. Only the first trip is operator adjustable.

G. Removal of a connected cylinder from the Tails LTTS is prevented by an interlock system. Unless the flexible hose on the cylinder valve has been removed and locked in its "holster," a physical barrier prevents the cylinder transporter drawbridge from docking with station rails, preventing cylinder removal.

H. Hydrocarbon lubricants are not used in any pumps. All tails pumps are lubricated with perfluorinated polyether (PFPE) oil, a fully fluorinated synthetic oil.

I. Temperature in the Tails Evacuation Pump/Chemical Trap Set mixed bed trap is monitored and controlled.

3.4.5.6 Operating Limits

The Tails Take-off System will have the capacity to remove the UF_6 tails on a continuous basis from the cascades at all rates under normal operating conditions. The system will also have the capacity to evacuate the full flow of UF_6 from the cascades under abnormal operating conditions.

3.4.5.7 Instrumentation

The process variables such as pressure, temperature, and valve positions, are automatically controlled. Deviations from the specified values are detected and indicated via a two level alarm system. An alarm, the operator has the ability to manipulate the process to restore it to normal. A second alarm, automatic action is taken to provide system protection. For safety, system protection and operability, sensors may be installed in duplicate (one out of two action) or triplicate (two out of three action). Action is initiated if any one out of two (or two out of three) sensor reaches alarm levels.

A. Primary Header.

There are two pressure transducers in each of the tails primary headers. Normal pressure is <4 mbar (<1.6 in. H_2O). First alarm (H) is a high to give operator warning of high pressure. Second alarm (HH) signals that the tails take-off system is unavailable, to protect the cascade from high pressure.

B. Tails Pumping Trains.

Each Tails Pumping Train inlet pressure is monitored. Normal pressure is <4 mbar (<1.6 in. H_2O). A alarm (H) gives operator warning of high pressure. A second alarm (HH) trips the vacuum pump off-line to protect the cascade from air ingress. A third alarm prevents the pump from running and the outlet valve from opening to protect against gross leakage into the system.

C. Secondary Header.

The tails secondary pipe header pressure is monitored with three sensors. Normal pressure is <55 mbar (<22.1 in. H_2O). An alarm provides operator warning of high pressure. A second alarm on two of three sensors, the vacuum pump trips off-line and a signal that the tails take-off system is unavailable goes to the programmable logic controller (PLC) in each cascade.

D. Tails Low Temperature Take-off Stations.

For pressure control, each tails cylinder inlet pressure is monitored. Normal pressure is <50 mbar (<20.1 in H_2O). An alarm gives the operator warning of high pressure. A second alarm automatically closes the Tails LTTS inlet valve and trips the Tails LTTS off-line.

For weight control, each Tails LTTS has a weighing system consisting of four load cells and a transmitter to monitor the contents of the UBCs. The first alarm, set at the net allowable weight of UF_6 for the 48-in cylinder, trips the Tails LTTS to standby to prevent overfilling. This promotes the standby auto Tails LTTS to on-line. The second trip, set at the gross allowable weight of a 48-in cylinder filled with UF_6, closes the inlet valve and trips the Tails LTTS to off-line. The output of the weighing system also allows 48Y tails cylinder weight to be verified to be within specified trending limits.

For temperature control and protection from high temperatures, the Tails LTTS has a stand-alone control and protection system. The total system consists of three sensors. For main Tails LTTS temperature control, one sensor is mounted in the air return to the chiller unit and 0monitors the circulating air temperature. This sensor and local control maintains the Tails LTTS temperature. In addition to controlling the station temperature, one output is monitored by the Plant Control System (PCS) and warns when the air temperature rises to a pre-determined temperature. This would indicate a chiller failure or that the defrost heater is not functioning properly. When the defrost heater is on, the circulating air fan is off to minimize the increase in Tails LTTS air temperature.

In addition to the closed loop control system previously described, there are two independent and diverse temperature protection instruments. These provide extra safety margin to protect against increases in temperature that may occur if the heater control does not operate properly. The first instrument is a fail-safe hardwired RTD and the second instrument is a fail-safe thermocouple. Both of these instruments measure the temperature of air inside the LTTS. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above their set point. If heater trip occurs from these two instruments, the Tails LTTS is automatically taken off-line and put into a standby mode. Both instruments are set to trip at a set point well below the calculated set point required to ensure cylinder integrity.

To prevent desublimation in the cylinder valve, the valve and inlet piping are electrically heated. A temperature sensor on the valve controls the temperature.

E. Tails Evacuation Pump/Chemical Trap Set

To prevent the activated carbon from overheating, there is one instrument that monitors the carbon trap temperature. This sensor will close the Tails LTTS vent valve when carbon trap temperature exceeds a pre-determined temperature. This blocks flow to the vacuum pump/chemical trap set. A flow restriction device is installed as a control feature on the suction of the vacuum to maintain a low flow rate. A flow restriction device is installed as a control feature on the vacuum pump suction to maintain a low flow rate.

3.4.5.8 Criticality Safety

The tails enrichment is less than 0.34%, which is inherently safe from a criticality standpoint. Piping and components used for the tails system are safe-by-design as shown in Table 3.7-8. Criticality safety for an assay dump at 1.5% enrichment to a single tails cylinder in the low-temperature take-off station is described in Section 3.4.8.8.3. The piping arrangement for the tails take-off system at 1.5% enrichment is analyzed in the product piping arrangement analysis.

3.4.6 (See SAR § 12.2.2.5) Product Blending System

3.4.6.1 Functional Description

The primary function of the Product Blending System is to provide a means to fill 30B product cylinders with UF_6 at a specified ^{235}U concentration (Ref. Figure 3.4-12, Process Flow Diagram Product Blending System). This is achieved by either transferring product from one donor cylinder into one receiver cylinder or blending product from multiple donor cylinders into one or more receiver cylinders.

Small intermittent quantities of gaseous effluent are produced from purging and evacuation of flexible piping during connection and removal of both donor and receiver cylinders. The effluent is treated in the Blending and Sampling Vent Subsystem to remove UF_6 and HF, and then discharged to the Pumped Extract GEVS for further treatment. Solid effluents are produced from periodic change-out of chemical and oil traps. There are no liquid effluents directly produced in this system. When the Blending and Sampling Vent Subsystem vacuum pump is taken out of service for maintenance, the oil is reprocessed in the CRDB for reuse.

The Product Blending System is located in the Blending and Liquid Sampling Area of the SBMs. They are operated from the Control Room, with the exception of preparation and maintenance activities that are performed locally at the equipment.

3.4.6.2 Major Components

The major components of the Product Blending System are listed below:

A. Blending Donor Station

A Blending Donor Station consists of an insulated box with a non-flammable insulated core. Each Blending Donor Station includes an electrical air heater and circulation fan to provide the thermal energy to sublime the solid UF_6 in the cylinder.

A weighing system is provided in the Blending Donor Station that consists of a weigh frame with four load cells. This system is used to provide continuous on-line weighing of the donor cylinder to monitor the quantity of UF_6. The Blending Donor Station weighing system is also used to indicate when the cylinder has transferred the required quantity of UF_6 and automatically close the Blending Donor Station outlet valve.

B. Donor Station Valve Hotbox

Valves in a Donor Station Valve Hotbox connect the donor cylinder to its Transfer Header, the Blending and Sampling Vent Subsystem, or the Nitrogen System. Manual and automatic isolation valves and pressure transducers are contained in the electrically heated Donor Station Valve Hotboxes to maintain them at a stable temperature. The UF_6 piping between the Blending Donor Station and Donor Station Valve Hotbox is heat traced.

C. Blending Transfer Headers

To provide operating flexibility there are two transfer headers that are used for transferring UF_6 from Blending Donor Stations to Blending Receiver Stations. Both UF_6 transfer headers are heat traced. In addition a vent header connects all the Blending Donor Stations and Blending Receiver Stations to the Blending and Sampling Vent Subsystem. The transfer headers are arranged such that a number of blending or transfer operations can take place at the same time.

D. Blending Receiver Station

A Blending Receiver Station consists of a composite panel box construction complete with rails for the electric carriage of the cylinder transporter. The Blending Receiver Station panels have a non-flammable insulated core and are vapor sealed to prevent ice build-up within the insulation. Each Blending Receiver Station incorporates an air chiller unit, with controls, to remove thermal energy from the UF_6 gas to cause it to desublime in the cylinder. The chiller unit has a defrost cycle, using a heater, to prevent ice buildup on the coils. Condensate from the chiller is routed to a safe-by-design drip plan to allow the water to evaporate. Electrical heating of the cylinder valve and inlet piping prevents UF_6 from desubliming and blocking the cylinder inlet. A weighing device is provided in the Blending Receiver Station (a frame with four load cells and associated instrumentation) to provide continuous on-line weighing of UF_6 in the receiver cylinder to prevent overfilling.

The front of the Blending Receiver Station is made up of a single door and the back is furnished with an opening to facilitate connection of the cylinder to the UF_6 piping. Seals on the openings in the Blending Receiver Station minimize leaks for energy conservation. The Blending Receiver Station access openings are provided with heat tracing to prevent ice build-up.

E. Receiver Station Valve Hotbox

Valves in the Receiver Station Valve Hotbox connect the Blending Receiver Station to both UF_6 Transfer Headers, the Blending and Sampling Vent Subsystem, or the Nitrogen System. Manual and automatic isolation valves and a pressure transducer are contained in the electrically heated Receiver Station Valve Hotbox to maintain them at a stable temperature. The UF_6 piping between the Receiver Station Valve Hotbox and the Blending Receiver Station is heat traced.

F. Blending and Sampling Vent Subsystem

The Blending and Sampling Vent Subsystem consists of a UF_6 cold trap with its heating and cooling systems and a vacuum pump/chemical trap set. The Blending and Sampling Vent Subsystem serves both the Product Blending System and the Product Sampling System. The Blending and Sampling Vent Subsystem contains the following major components.

1. UF_6 Cold Trap.

The UF_6 cold trap consists of an insulated horizontal tube with internal baffles. It also has a dedicated heater/chiller unit operating at a cooling set point and a heating set point. The heater/chiller unit contains approximately 70 L (19 gal) of silicon oil, as a heat exchange media, which circulates around the cold trap. The low temperature removes the thermal energy from the UF_6 gas, causing it to desublime on the internal walls of the UF_6 cold trap, while leaving the light gas in the gaseous phase. The high temperature results in sublimation of the UF_6 contents of the UF_6 cold trap for transfer back to a receiver cylinder. Each end of the UF_6 cold trap is heat traced to prevent the UF_6 from solidifying and blocking the UF_6 cold trap entrance or exit. The UF_6 cold trap has a weighing device to provide continuous on-line weighing of the UF_6 accumulated.

An automatic control valve located after the UF_6 cold trap restricts the flow of gases through the UF_6 cold trap. This ensures an adequate residence time for the gases in the UF_6 cold trap to allow all of the UF_6 to desublime.

The UF_6 cold trap also provides the capability for emptying sample bottles, using a small manifold located upstream of the UF_6 cold trap. The temperature difference of the sample bottle at ambient and the UF_6 cold trap allows the UF_6 to outgas without heating the bottle.

2. Vacuum Pump/Chemical Trap Set.

The UF_6 cold trap is followed by a vacuum pump/chemical trap set. The set consists of a carbon trap, an aluminum oxide trap, an insulated vacuum pump with nitrogen purge, and an oil trap on either side of the pump. The pump exhausts into the Pumped Extract GEVS.

The activated carbon trap removes any traces of UF_6 not desublimed in the UF_6 cold trap. HF is removed from the gas flow by the aluminum oxide trap. These traps are installed upstream of the vacuum pump. Oil traps are installed before (an aluminum oxide trap) and after (mechanical trap (exhaust filter)) the vacuum pump to prevent diffusion of oil, both back into the Blending and Sampling Vent System and discharge into the Pumped Extract GEVS.

3.4.6.3 Design Description

The design bases and specifications are given in Table 3.4-8, Product Blending System Design Basis. Applicable codes and standards are given in Table 3.4-9, Product Blending System Codes and Standards.

The Product Blending System is sized for the complete 3,000,000 SWU/yr enrichment plant capacity. Gaseous UF_6 is transferred from the Blending Donor Stations to the Blending Receiver Stations through a system of valves and transfer headers.

The entire Product Blending System operates at subatmospheric pressure. In the event of a confinement barrier failure (e.g., pipe leak), releases of UO_2F_2 and HF are greatly minimized because air would migrate into the system rather that UF_6 exiting the system. This important safety feature greatly limits the likelihood of worker and public exposures.

There are two Blending Donor Stations with valve hotboxes, each connected to one of the two transfer headers in the Product Blending System. At any time one or both stations, each connected to a different header, can be on-line to handle the various blending or transfer operations.

There are two Blending Receiver Stations, each with a valve hotbox, connected in parallel to the two transfer headers. Any number of Blending Receiver Stations can be connected to a single header at any one time, but a single Blending Receiver Station cannot be connected to both headers at the same time.

The pressure in each UF_6 transfer header is limited to 500 mbar (7.25 psia). To prevent UF_6 desublimation at ambient building temperatures, the headers are heat traced. Building ambient temperature is maintained above 18°C (64.4°F).

All components and piping in the Product Blending System operate at subatmospheric pressure. Release of UF_6 and/or HF is unlikely because leakage, if it were to occur, would be into the system.

Materials of construction and fabrication specifications for the equipment and piping used in the Product Blending System are compatible with UF_6 at the operating conditions and have been proven by over 30 years of use in existing Urenco European enrichment plants.

3.4.6.4 Interfaces

The Product Blending System interfaces with the following systems and utilities.

A. Pumped Extract GEVS
B. Plant Control System
C. Nitrogen System
D. Compressed Air System
E. Electrical System
F. Hoisting and Transportation Equipment.

3.4.6.5 Design and Safety Features

The Product Blending System is designed and constructed to provide safe operation for plant personnel as well as the general public. Principal design features are as follows:

A. All process piping, valves, vessels and pumps in the Product Blending System operate at subatmospheric pressure.
B. Piping is all welded construction and process valves are bellows sealed.
C. Before disconnecting any equipment, the process piping is evacuated and purged with nitrogen.

D. A local exhaust to the Pumped Extract GEVS is provided via a temporary local extract cross-connection, for initial plant operations, any time a UF_6 line is disconnected.

E. Before discharge to the Pumped Extract GEVS, all gases flow across activated carbon and aluminum oxide in the Blending and Sampling Vent Subsystem chemical traps to remove any traces of UF_6 and HF.

F. Temperature in each Blending Donor Station and Blending Receiver Station is monitored and controlled.

G. Receiver cylinder overfill is prevented by two weight trips. The first is at the desired net weight of UF_6 and the second is at the gross weight of the cylinder with UF_6 contents. Only the first trip is operator adjustable.

H. Hydrocarbon lubricants are not used. The Blending and Sampling Vent Subsystem vacuum pump is lubricated with perfluorinated polyether (PFPE) oil, a fully fluorinated synthetic oil.

I. Removal of a connected cylinder from a Blending Donor Station or a Blending Receiver Station is prevented by an interlock system. Unless the flexible hose on the cylinder valve has been removed and locked in its "holster," a physical barrier prevents the cylinder transporter drawbridge from docking with the station rails, preventing cylinder removal.

J. Temperature in the Blending and Sampling Vent Subsystem carbon trap is monitored and a trip on high temperature causes an alarm.

K. Should a blockage occur in a section of process piping, the heat tracing on that section of pipe is not allowed to be switched on until the solid UF_6 has been removed.

3.4.6.6 Operating Limits

The Product Blending System is capable of handling the enrichment blending requirements of the entire plant. Since customers' enrichment requirements are generally met by adjustments to the enrichment process, blending is not always necessary.

3.4.6.7 Instrumentation

The process variables, such as pressures, temperatures and valve positions are automatically controlled. Deviations from the specified values are detected and indicated by two level alarm systems. At the first alarm, the process operator has the ability to manipulate the process to restore it to normal. At the second alarm, automatic action is taken to provide system protection. For safety, system protection, and operability, some sensors are duplicated. Action is initiated if any one out of two sensors reach alarm levels.

A. Blending Donor Station.

Both the Blending Donor Station air temperature and cylinder temperature are monitored to prevent over pressurization of the donor cylinder due to overheating. An alarm is 62°C (144°F) for the Blending Donor Station air and 54°C (129°F) for the cylinder to give the operator warning of high temperature. A second alarm is for the cylinder, which trips the Blending Donor Station heater off.

In additional to the above temperature controls, the Blending Donor Station has two independent and diverse temperature protection instruments. The first instrument is a fail-safe hardwire RTD and the second instrument is a fail-safe thermocouple. Both instruments measure the Blending Donor Station air temperature. Both instruments automatically de-energize the heater and blower if the Blending Donor Station air temperature rises above their set point.

Both instruments are set to trip at a set point which is well below the calculated set point required to ensure cylinder integrity.

The donor cylinder pressure is monitored with dual sensors to prevent over-pressurization. An alarm gives the operator warning of high pressure. A second alarm automatically closes the cylinder valve and trips the Blending Donor Station off-line. A low pressure alarm warns that a cylinder vent is complete.

Each Blending Donor Station has a weighing system to monitor the mass of UF_6 remaining in the donor cylinder. A weight trip is used to indicate a cylinder is present in the Blending Donor Station. A second weight trip, equal to the net cylinder contents weight after meeting the receiver cylinder requirements, indicates that the target transfer weight has been reached and trips the Blending Donor Station to standby. A third weight trip signals that the donor cylinder is empty and trips the Blending Donor Station to standby.

B. Blending Receiver Station.

The weight of the receiver cylinder is monitored to determine when the required amount of UF_6 has been transferred and to protect against overfilling the cylinder. A low weight trip at indicates that a cylinder is present in the Blending Receiver Station. The Blending Receiver Station trips to standby and automatically closes the inlet valve when the required transfer weight is reached. A second trip, at the maximum net weight for a 30B cylinder, also trips the Blending Receiver Station to standby and closes the inlet valve. A third trip, at the maximum gross weight for a 30B cylinder, closes the inlet valve and trips the Blending Receiver Station off-line. The output of the weighing system also allows cylinder weight to be verified to be within specified trending limits.

The receiver cylinder inlet pressure is monitored to assure that a cylinder is connected to the system. Normal pressure is from 0 to 500 mbar (0 to 7.25 psia). An alarm warns the operator of high pressure. A second alarm automatically closes the Blending Receiver Station inlet valve and trips the Blending Receiver Station off-line.

For temperature control and protection from high temperatures, the Blending Receiver Station has a stand-alone control and protection system. The total system consists of three sensors. For main Blending Receiver Station temperature control, one sensor is mounted in the air return to the chiller unit and monitors the circulating air temperature. This sensor and local control maintains the Blending Receiver Station temperature to a normal value. In addition to controlling the Blending Receiver Station temperature, one output is monitored by the Plant Control System and warns when the air temperature rises. This would indicate a chiller failure or that the defrost heater is not functioning properly. When the defrost heater is on, the circulating air fan is off to minimize the increase in Blending Receiver Station air temperature.

In addition to the closed loop control system previously described, there are two independent and diverse temperature protection instruments. These provide extra safety margin to protect against increases in temperature that may occur if the heater control does not operate properly. The first instrument is a fail-safe hardwired RTD and the second instrument is a fail-safe thermocouple. Both of these instruments measure the Blending Receiver Station air temperature. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above their set point. If heater trip occurs from these two instruments, the Blending Receiver Station is automatically taken off-line and the transfer sequence stopped.

Both instruments are set to trip at a set point which is well below the calculated set point required to ensure cylinder integrity.

To prevent desublimation in the cylinder valve, the valves and inlet piping are electrically heated. A temperature sensor on the valve controls the temperature.

C. Blending and Sampling Vent Subsystem UF_6 Cold Trap.

During the venting operation, the Blending and Sampling Vent Subsystem UF_6 cold trap outlet pressure is monitored. A high alarm warns of high pressure in the UF_6 cold trap. A second high alarm trips the UF_6 cold trap off-line, switching the heater/chiller unit off and closing the inlet/outlet valves. A low alarm warns of low pressure and indicates the UF_6 cold trap is empty when collected UF_6 is being sublimed for transfer back to a receiver cylinder (i.e., gas back). A second low alarm automatically closes the UF_6 cold trap outlet valve to prevent UF_6 flow to the vacuum pump. A weighing system monitors the UF_6 contents of the UF_6 cold trap. A first alarm warns that the UF_6 cold trap is full. At a system description set weight the UF_6 cold trap trips off-line, the inlet and outlet valves are closed, and a gas-back sequence is required.

The temperature of the UF_6 cold trap is controlledduring cooling to desublime any UF_6 and for heating during sublimation to empty the UF_6 cold trap of collected UF_6 (gas back). A low alarm warns of a chiller unit fault. A high alarm closes the UF_6 cold trap outlet valve and a second high alarm warns of high temperature during gas back. If temperature continues to rise the UF_6 cold trap trips off-line to avoid desublimation of UF_6 in the header.

D. Blending and Sampling Vent Subsystem Vacuum Pump/Chemical Trap Set.

To prevent the carbon trap from overheating and overfilling with UF_6, there is one instrument. The sensor monitors the carbon trap temperature. When the high temperature setpoint is reached, an alarm is activated.

3.4.6.8 Criticality Safety

3.4.6.8.1 Product Cylinders

(Same as Section 3.4.4.8.1 for the Product Take-off System)

3.4.6.8.2 UF_6 Cold Trap

(Same as Section 3.4.4.8.2 for the Product Take-off System)

3.4.6.8.3 Vacuum Pump / Chemical Trap Set

(Same as Section 3.4.4.8.3 for the Product Take-off System)

3.4.7 (See SAR § 12.1.2.6) Product Liquid Sampling System

3.4.7.1 Functional Description

The primary function of the Product Liquid Sampling System is to provide a means to validate the precise mean concentration of uranium-235 (^{235}U) and the purity of uranium hexafluoride (UF_6) in the product by taking homogenized liquid UF_6 samples from each product cylinder (Ref. Figure 3.4-13, Process Flow Diagram Product Liquid Sampling System). All product cylinders are sampled prior to being released for shipment to the customer.

The sampling process is carried out with UF_6 in the liquid state. At ambient temperature, the product in the 30B cylinders is in solid form when the cylinders are placed in the autoclave. Heating the cylinders in the autoclave transposes the UF_6 from the solid phase to the liquid phase. Once in the liquid phase, the cylinder is held at temperature for a sufficient period of time to assure homogenization. After homogenizing, the autoclave is tilted to pour the liquid into the sampling manifold and then into the sample bottles.

In the liquid phase, the pressure in the product cylinders is above atmospheric. The autoclaves provide a secondary confinement barrier and protection in the event a cylinder or sampling manifold should leak.

The system is shown in Figure 3.4-13, Process Flow Diagram Product Liquid Sampling System.

3.4.7.2 Major Components

The Product Liquid Sampling System consists of only one main piece of equipment – the Product Liquid Sampling Autoclave. The Product Liquid Sampling Autoclave is shown in Figure 3.4-14, Liquid Sampling Autoclave Equipment Drawing. The autoclave consists of numerous parts that are all integrated together into one machine (the autoclave). The primary parts of each autoclave are a secondary confinement barrier pressure vessel, tilting mechanism, external cooling water coils and exterior insulation. Also included inside the pressure vessel are a cylinder support frame and rails, electric air heaters and air circulation fan, and a sampling manifold. There is a stand-alone control system and instrumentation.

All components of the autoclave are constructed of materials that have been used in existing Urenco plants for over 30 years. The autoclave pressure vessel is constructed of carbon steel to ASME specifications. The sampling manifold is constructed of Monel. The autoclave is designed to sustain seismic loading without a loss of integrity.

In normal operation, the Product Liquid Sampling System is vented during sample manifold connection and disconnection via a system that is shared with the Product Blending System.

A brief description of each major component of the Product Liquid Sampling System is provided below:

A. Cylindrical Pressure Vessel (Secondary Confinement Barrier).For sampling, the 30B product cylinders (primary confinement barrier) are loaded into the cylindrical pressure vessel (secondary confinement barrier) that is mounted horizontally. In the event of an accidental release of product during the sampling operation, the pressure vessel provides confinement of any UF_6, UO_2F_2, and HF. The pressure vessel is designed and fabricated in accordance with the requirements of ASME Section VIII, Division1, with the exception that the pressure relief devices specified in Sections UG-125 through 137 are not provided due to the potential for release of hazardous material to the environment through a pressure relief device. Instead, two independent and diverse automatic trips of the autoclave heaters and fan motor are provided to eliminate the heat input and preclude approaching the autoclave design pressure. This is considered to be acceptable due to the large margin between the autoclave design pressure 12 bar (174 psia) and the maximum allowable working pressure 1.8 bar (26 psia) and the fail-safe design of the two independent and diverse automatic trips of the autoclave heaters and fan motor. The pressure vessel is also tested and stamped to the requirements of ASME Section VIII, Division 1 rules and is registered with the National Board. The pressure vessel design pressure is 12 bar (174 psia) absolute and the design temperature is 160°C (320°F). One end of the pressure vessel has a welded on (stationary) dished head. On the other end is a swing out door assembly that consists of a dished head, sealing ring, gaskets, and a locking device to lock the head assembly in place after the door is closed. There are dual gaskets to provide high sealing integrity.

B. Cylinder Support Frame and Rails.

A support frame is inside the pressure vessel. The frame is designed to contain the 30B cylinder. The support frame has rails that match the rail transporter rail design. When the cylinder is inserted in the autoclave, the frame and rails prevent the cylinder from moving when the pressure vessel is tilted. The support frame also prevents the cylinder from moving out of position during any abnormal event (such as seismic).

C. Electric Heaters and Fan.

Three electric heaters heat the inside of the autoclave. In addition to the three heaters, there is one variable speed fan that provides forced circulation of hot air over the exterior of the cylinder.

D. Sampling Manifold.

A sampling manifold is connected to the cylinder isolation valve and attached to the cylinder skirt to provide mechanical support, after the cylinder is in place. The sampling manifold is a single pipe, fabricated to provide three drain points for connection of three type 1S sample bottles to the cylinder. The total volume of the sampling manifold is such that the volume of UF_6 held in the manifold, when filled, will provide a sample of the required volume into each of the three sample bottles.

E. Cooling Coils.

The autoclave is cooled with coils mounted on the exterior of the pressure vessel. Cooling media is supplied from Air Cooled Chillers.

F. Insulation.

The external surfaces of the pressure vessel are insulated for energy conservation. The insulation is non-flammable.

G. Tilting Mechanism.

The tilting mechanism raises and lowers the end of the pressure vessel with the fixed head (opposite the door end), while the other end rotates around hinge pins located under the pressure vessel. The tilting mechanism provides three positions:

- When the sample manifold is being filled, the tilting mechanism sets the incline to 30° from horizontal. At this incline, liquid UF_6 pours from the cylinder into the sampling manifold.
- For cylinder loading and unloading, the tilting mechanism sets the centerline of the pressure vessel parallel to the floor (0°).
- When the cylinder is in warm-up, homogenization, and cooling, or the manifold is being cleared, the tilt mechanism sets the autoclave at –2° from horizontal.

H. Stand Alone Control System.

The autoclave has a stand-alone control system. This system and its associated instrumentation are described in Section 3.4.7.7, Instrumentation.

I. Blending and Sampling Vent Subsystem.

Venting of the Product Liquid Sampling System is performed using the same equipment as is used for the venting of the Product Blending System. The Blending and Sampling Vent Subsystem equipment consists of a UF_6 cold trap with heater and chiller unit, and a vacuum pump/chemical trap set that includes carbon and aluminum oxide traps and a vacuum pump.

3.4.7.3 Design Description

The design bases and specifications are given in Table 3.4-10, Product Liquid Sampling System Design Basis. Applicable codes and standards are given in Table 3.4-11, Product Liquid Sampling System Codes and Standards.

There are three Liquid Product Sampling Autoclaves at the NEF with one allocated to process flexibility, maintenance, etc.

The Product Liquid Sampling System consists of autoclaves that liquefy and homogenize the UF_6 contained in international 30B cylinders. This process is accomplished by passing hot air over the cylinders at a controlled rate.

For normal operation, a filled 30B product cylinder is loaded into an autoclave by rail from the cylinder transporter, and secured by clamps to prevent movement when the autoclave is tilted.

The sampling manifold is connected to the cylinder valve and secured to the cylinder skirt. The manifold is then connected to the Blending and Sampling Vent Subsystem. It is purged with nitrogen and pressure tested, and then evacuated and vacuum tested. With the manifold evacuated, the vent system is disconnected and the cylinder valve is opened by hand. The cylinder valve is verified as open and not blocked, and the cylinder starting pressure is verified as suitable to continue. Then the manual actuator used to close the cylinder valve is connected to allow the valve to be closed from the outside of the autoclave. The manual actuators for the sample bottle valves are also connected.

The autoclave door is then closed and locked.

The autoclave is pressurized at ambient temperature to approximately 1,200 mbar (17.4 psia) absolute pressure with nitrogen. This assures a slight pressure (above atmospheric) still exists at the end of the sampling cycle, following cooling. The positive pressure allows the autoclave to vent and ensures some gas flow to the HF monitor located in the line to the Pumped Extract GEVS.

The autoclave is then tilted to the –2° position to reduce the potential for splash over of UF_6 into the manifold during heat-up. The electric heaters and fan are then actuated and the internal temperature in the autoclave is brought up to operating temperature.

Hot air forced over the cylinder raises the UF_6 temperature to change the solid UF_6 to liquid. When the measured UF_6 pressure reaches its control set point and the cylinder contents are in equilibrium, the temperature set point remains steady.

When the pressure set point of 2.5 bar (36.3 psia) is reached, the autoclave maintains the pressure and temperature so the UF_6 can homogenize. This homogenizing period lasts for approximately 16 hours.

After homogenization, the sampling procedure begins. With the sample bottles closed, the heater controller is changed over to temperature control and the set point for the air temperature is elevated slightly. Due to the much smaller mass of the sample manifold compared to the cylinder, the sample manifold will heat up quicker than the cylinder. Any liquid UF_6 within the sample manifold piping vaporizes and flows back into the cylinder and condenses.

The air heaters and fan are then switched off.

After the heaters and fan are off, the autoclave is tilted to 30°. The liquid UF_6 flows from the product cylinder into the sampling manifold (which has three 1S sample bottles connected to it). To avoid overfilling of the bottles, the volume of the pipe on each branch from the manifold to the bottle is less than the volume of the sample bottle.

After pouring liquid UF_6 into the sampling manifold, the autoclave is returned to the –2° position and the valves on the sample bottles are opened to fill the bottles with liquid UF_6. The valves of the sample bottles are then closed.

The air heaters and fan are switched on and the temperature set point is increased slightly. The remaining liquid UF_6 within the sampling manifold is vaporized and re-condenses in the cylinder. This removes any residual liquid UF_6 from the manifold.

Following the sampling operation and removal of the residual liquid UF_6 from the manifold, the cylinder valve is closed. The autoclave and the cylinder are cooled down by circulating cooling water through the cooling coils until the pressure in the cylinder is subatmospheric and the liquid UF_6 goes back to the solid state.

The autoclave is then returned to the horizontal position. Once the autoclave is validated to be free of any UF_6 and HF, the door is opened.

The sample manifold is purged with nitrogen and vented to the Blending and Sampling Vent Subsystem UF_6 cold trap and vacuum pump/chemical trap set.

The three sample bottles are removed and taken to the laboratory. One bottle is analyzed, one is sent to the customer, and one is held as a reference sample.

The cylinder is then removed from the autoclave by the cylinder transporter.

3.4.7.4 Interfaces

The Product Liquid Sampling System interfaces with the following systems and utilities.

A. Blending and Sampling Vent Subsystem
B. Pumped Extract GEVS
C. Nitrogen System
D. Compressed Air System
E. Electrical System
F. Hoisting and Transportation Equipment
G. Plant Control System.

3.4.7.5 Design and Safety Features

The Product Liquid Sampling System is designed and constructed to provide safe operation for plant personnel as well as the general public. Releases to the atmosphere are minimized by:

A. Cylinder fill mass is limited to ensure cylinder integrity by verifying the weight of product cylinder is within limits before placement and heating in the autoclave.

B. Any heating, handling, or sampling of UF_6 in its liquid state is done in a sealed autoclave to provide secondary confinement in the event of leakage of the primary confinement barrier. The autoclave is not opened until the UF_6 is cooled to a solid and the cylinder is returned to less than atmospheric pressure.

C. Temperature in each autoclave, and of the cylinder being sampled, is monitored and controlled.

D. Abnormal temperature in each autoclave is detected via temperature sensors and indicated by alarms. Appropriate actions to shut down the systems are taken as necessary.

E. Abnormal pressure in each autoclave, and in the cylinder being sampled, is detected via pressure sensors and indicated by alarms. Appropriate actions to isolate the process or shut down the systems are taken automatically.

F. Before opening the autoclave or disconnecting the sampling manifold, the equipment and process piping is evacuated and purged with nitrogen.

G. A local exhaust to the Pumped Extract GEVS is provided for initial plant operations via a temporary local extract cross-connection any time the autoclave is opened or the sample manifold is disconnected.

H. Before discharge to the Pumped Extract GEVS, the vent gases flow through the UF_6 cold trap and then across activated carbon and aluminum oxide in the Blending and Sampling Vent Subsystem to remove any traces of UF_6 and HF.

I. Temperature and weight in the Blending and Sampling Vent Subsystem carbon trap is monitored and a trip on weight and a trip on temperature stops the Blending and Sampling Vent vacuum pump.

J. The autoclave is designed and tested to ensure leak tight integrity is maintained.

K. The autoclave door seal is leak tested and inspected prior to each autoclave sample sequence.

3.4.7.6 Operating Limits

The Product Liquid Sampling System is capable of handling the sampling requirements of the entire plant. The system is designed to allow flexibility by providing for the sampling of up to an equivalent of nine product cylinders per week. This number provides a margin based on the 3,000,000 SWU per year rated capacity of the NEF.

3.4.7.7 Instrumentation

Each autoclave is controlled by a stand-alone control system. This system carries out all the control and protection functions as well as providing interface with the Plant Control System. There is a local operator interface (LOI) at each autoclave. From the LOI an operator can control all functions of the autoclave, as well as start and stop the autoclave process. All process variables are displayed at the LOI and are relayed to, and displayed in, the Control Room.

The process variables, such as pressures, temperatures, and interlock positions, are automatically controlled. Deviations from specified values are detected and indicated via two level alarm systems. At the first alarm level, the process operator has the ability to manipulate the process to restore it to normal. At the second alarm level, automatic action is taken to provide system protection. For safety, system protection, and operability, some critical sensors are duplicated. Action is initiated if any one out of the two sensors reach alarm levels.

A. Product Liquid Sampling Autoclave.

Two pressure sensors, connected to the cylinder by the sampling manifold, monitor and control the cylinder pressure during heating, homogenization, and sampling. Normal pressure during homogenization and liquid sampling is less than 3.0 bar (43.5 psia). The first alarm level is 3.0 bar (43.5 psia) to give operator warning of over pressurization. The second alarm level is 3.2 bar (46.4 psia), which automatically de-energizes the air heater and fan. A second cylinder pressure monitor with the same alarm levels provides backup protection.

Pressure inside the autoclave is monitored with a single sensor. A first high switch, at 1.1 bar (16 psia), prevents the door from being opened while the autoclave is under pressure. A second high switch at 1.2 bar (17.4 psia), which is the normal operating pressure of the autoclave at the start of heating, closes the nitrogen supply valve. The third high alarm level, at 1.5 bar (21.8 psia), gives the operator warning of over pressurization. The final high alarm level is 1.8 bar (26.1 psia) and automatically de-energizes the autoclave heaters and aborts the cycle – manual resetting of the sample cycle is required.

A temperature sensor monitors the surface of the cylinder during heating and cooling. A temperature above 55°C (131°F) prevents the autoclave door from being opened. This ensures that the UF_6 is solid before the cylinder can be removed from the autoclave.

Dual temperature sensors monitor the autoclave air temperature for control and protection. One sensor modulates power to the heaters to control the autoclave air temperature. The other sensor provides no control, but monitors and protects the autoclave air temperature only. Both sensors provide protection by a one from two voting system. Normal temperature during heating is less than 110°C (230°F). A first switch at 40°C (104°F) prohibits unlocking the autoclave door until the autoclave has cooled at the end of the sampling cycle. An alarm at 110°C (230°F) warns the operator of high temperature. The third alarm level at 115°C (239°F) automatically de energizes the autoclave heater and fan.

Each of the three autoclave heater elements has a temperature switch at 150°C (302°F) to protect the element. The air circulating fan motor is protected using a temperature sensor with a high warning alarm and a switch to de-energize the heaters and fan.

An HF monitor in the common vent header from the autoclaves to the Pumped Extract GEVS provides a backup check to verify the quality of the air venting from the autoclave. If HF is detected here the shotbolts lock and prevent the autoclave doors from opening and an alarm signals to manually close the open autoclave vent valve, and the other autoclave vent valves cannot be opened.

In addition to the process control noted above, there are six timers associated with the various steps of the sampling cycle.

Two timers provide for monitoring the autoclave to maintain safe start-up of the heating cycle. The value of these two timers is made to enable monitoring of the autoclave pressure rise during the start of the heating cycle verses time. The autoclave pressure is compared to an algorithm during the first phase of the heating stage when the heating is carried out with a preset air temperature. If the pressure rise conforms to the algorithm, the heating is permitted to advance to a second phase where the heating is controlled by the cylinder pressure. In the event the algorithm is not being met, the heating cycle is aborted.

Two other timers operate to monitor the quality of the air space in the autoclave and support the operation of the internal HF monitor. After the system stabilizes, the autoclave air pressure and temperature are compared. A departure from the anticipated pressure to temperature ratio indicates a leak has occurred. A lower than anticipated pressure to temperature ratio indicates a pressure leak from the secondary containment (autoclave). A higher than anticipated ratio indicates a leakage of UF_6 into the secondary containment. If the pressure/temperature ratio is outside the anticipated range, the cycle is aborted.

Another timer is used to confirm that the cooling cycle is continued for a sufficient time to ensure the cylinder contents are solidified before the cylinder is removed from the autoclave.

A final timer ensures that the autoclave is fully vented before the autoclave door is opened.

B. Blending and Sampling Vent Subsystem.

The instrumentation for the Blending and Sampling Vent Subsystem equipment is discussed in Section 3.4.6, Product Blending System.

3.4.7.8 Criticality Safety

Table 3.7-10 provides the safe-by-design components used for the Product Liquid Sampling System. Criticality safety for these items is bounded by similar or identical items provided for the Product Take-off System. No additional calculations are necessary.

3.4.8 (See SAR § 12.2.2.7) Contingency Dump System

3.4.8.1 Functional Description

The Contingency Dump System (Ref. Figure 3.4-15, Process Flow Diagram Contingency Dump System) provides an exhaust route for UF_6 from the cascade in the event of the cascade operating outside of its design envelope. The Contingency Dump System also provides an evacuation route for UF_6 and light gases to allow the centrifuges to be safely run down to rest.

Dumping of the UF_6 from the cascade, should the need arise, will take place by first choice to the Tails Take-off System. If the Tails Take-off System becomes unavailable, the NaF traps are used. The Contingency Dump System is designed to operate in one of two principal operating modes, passive evacuation or active evacuation. The function of the passive evacuation mode is to trap the UF_6 evacuated from the cascade in the sodium fluoride (NaF) traps. This "passive evacuation" is so called because evacuation of the cascade can initially take place without actively pumping; the low pressure maintained in the NaF traps and buffer volume in standby mode facilitates this process. Operation in the passive evacuation mode results in a progressive increase in the operating pressure at the NaF traps due to the accumulation of light gas in the buffer volume. This light gas is removed from the buffer volume by operation in the active evacuation mode. In "active evacuation" the buffer volume is opened to the vacuum pump/chemical trap set and the light gas is exhausted from the passive system via the carbon and aluminum oxide traps to the Pumped Extract GEVS.

3.4.8.2 Major Components

The major Contingency Dump System components are listed below.

A. Contingency Dump System NaF Traps and Buffer Volume.

A pressure transducer is located on the cascade header to monitor conditions at the cascade header during dump. This transducer is dedicated to the Dump Control System and provides an indication of cascade conditions during dump.

The Contingency Dump System uses three chemical traps (Ref. Figure 3.4-16, NaF Trap Equipment Drawing) filled with sodium fluoride (NaF). This material is able to adsorb UF_6 and HF without producing gaseous reaction products. The buffer volume provided after the NaF traps accommodates any light gas that passes through the NaF traps. The NaF traps and buffer volume constitute the "passive" part of the Contingency Dump System. This passive part of the Contingency Dump System is able to maintain a dump capacity in the event of a loss of other services or utilities.

Automatic valves are provided for plant operation. Pressure transducers are positioned in the Contingency Dump System to monitor both the buffer volume pressure and dump pump suction pressure. This monitoring is for both the operation and protection of the Contingency Dump System and the prevention of backflow of light gases through the NaF traps to the Cascade System.

A fourth pressure transducer is mounted at the cascade valve frame between the automatic and manual valve to enable monitoring of the seating efficiency of these two valves. A tight shut-off of the valve must be maintained throughout the life of the Contingency Dump System to prevent the NaF traps becoming loaded with UF_6. A tight shut-off valve is required to enable maintenance of the Contingency Dump System.

B. Contingency Dump System Vacuum Pump/Chemical Trap Set.

The Contingency Dump System Vacuum Pump/Chemical Trap Set major components are:

- A roots type and rotary vane vacuum pump
- A mixed-bed activated carbon and aluminum oxide trap

The NaF traps and buffer volume of the passive dump system are backed by the Contingency Dump System Vacuum Pump/Chemical Trap Set which comprises, in order, a Roots type vacuum pump, mixed-bed (activated carbon and aluminum oxide (Al_2O_3)) trap and sliding vane type vacuum pump with an aluminum oxide oil trap on the pump suction and a mechanical oil trap (exhaust filter) on the pump discharge. The sliding vane vacuum pump discharges into the Pumped Extract GEVS. Connection of the Contingency Dump System vacuum pump/chemical trap set is made to the NaF traps/buffer volume of the Contingency Dump System by flexible stainless steel vacuum bellows and to the Pumped Extract GEVS by a pressure hose. The equipment is assembled as a modular package to facilitate easy replacement and maintenance of the unit as a whole in the event of a failure.

The function of the activated carbon in the mixed bed trap is to remove small traces of UF_6 and the aluminum oxide is to remove any HF from the gas flow. The oil traps prevent oil migration both upstream and into the Pumped Extract GEVS.

To maintain a high availability of the Contingency Dump System, power supply to the Contingency Dump System pumps is maintained by standby diesel generators in the event of a failure of the normal power supply. Each cascade has one Contingency Dump System that directs a cascade dump either to the Tails LTTS or the NaF traps.

3.4.8.3 Design Description

The design bases and specifications are given in Table 3.4-12, Contingency Dump System Design Basis. Applicable codes and standards are given in Table 3.4-13, Contingency Dump System Codes and Standards.

An independent Contingency Dump System is provided for each cascade. All components of the Contingency Dump System operate a subatmospheric pressure. Release of UF_6 or light gases is minimized because leakage, if it were to occur, would be inward to the system.

All of the process equipment in the Contingency Dump System is designed, constructed, and operated using good engineering practice and in accordance with the LES Quality Assurance program.

The materials of construction, corrosion allowances and fabrication specifications for the equipment and piping used in the Contingency Dump System are compatible with UF_6 and HF at the operating conditions and have been proven by extensive use in existing enrichment plants.

3.4.8.4 Interfaces

The Contingency Dump System interfaces with the following systems and utilities:

A. Cascade System
B. Pumped Extract GEVS
C. Nitrogen System
D. Compressed Air System
E. Electrical System
F. Plant Control System.
G. Tails Take-off System

3.4.8.5 Design and Safety Features

This system is designed and constructed to provide safe operation for plant personnel as well as the general public. Principal design features are as follows:

A. All piping, vessels and pumps in the Contingency Dump System operate at subatmospheric UF_6 pressure.
B. Piping is all welded construction and process valves are bellow sealed.
C. Before carrying out any disconnections or connections of equipment, the piping is evacuated and nitrogen purged. Flexible exhaust hoses connected to the Pumped Extract GEVS via a temporary local extract cross-connection, during initial plant operations, remove any releases from the work area.
D. Before discharge to the Pumped Extract GEVS, all gases flow across activated carbon and aluminum oxide to remove any traces of UF_6 and HF via the Contingency Dump System Vacuum Pump/Chemical Trap Set.
E. Monitoring of fill level of NaF trap when charging the NaF trap.

F. Hydrocarbon lubricants are not used. The rotary vane vacuum pumps are lubricated with perfluorinated polyether (PFPE) oil, a fully fluorinated synthetic oil.

G. The potential for capture of UF_6 and HF in the NaF traps is maximized by operation of the Contingency Dump System in a passive mode. In passive evacuation mode the flow of UF_6 from the cascade is restricted to the NaF traps and buffer volume by valving.

H. The main electrical supply is supported by a Standby Diesel Generator System for electrical services essential to equipment protection. In the case of a power failure the UF_6 valves will retain their position because their control is via a 24 VDC uninterruptible power supply (UPS). On loss of the UPS the valves will revert to a fail-safe position.

I. Compressed air has a high reliability in normal operation with sufficient capacity at the pressure reservoir for a safe shut down. To protect against a compressed air failure, all air driven valves are fitted with check valves to ensure that the valve retains a position of at least 50% for six hours.

J. The potential for a criticality arising in the systems and components associated with a cascade dump (e.g., Tails LTTS, 48Y cylinder, NaF traps buffer volume, piping, etc.) is prevented byenrichment control, which limits the upper bound for the average enrichment of the assay (1.5%). The systems and components associated with a cascade dump are bounded by this average cascade enrichment and the criticality safety approvals for the items are granted based on 1.5% ^{235}U.

3.4.8.6 Operating Limits

The Contingency Dump System must be able to remove the UF_6 content of the cascade and evacuate to a minimum pressure during abnormal operating conditions.

3.4.8.7 Instrumentation

The cascade protection system is provided by two Programmable Logic Controllers (PLCs), one PLC controlling and protecting the process while the other PLC monitors parameters essential to the separation process and takes action if these parameters are out of specification. In the event of a failure of either of the PLCs, the failure will invoke a cascade dump.

The Contingency Dump System process variables such as pressures and valve positions are displayed in the Control Room and are automatically controlled by the Contingency Dump System Local Control Center (LCC). Deviations from the specified values are detected and indicated via two-tiers of signals. At the first level the signal provides an alarm only and the process operator has the ability to manipulate the process to restore it to normal operation. At the second alarm/trip level, automatic action is taken to provide system protection.

The pressure transducers and valve and pump status signals of the Contingency Dump System are directly connected to the control PLC in the Contingency Dump System LCC.

The dump system has two distinct modes of operation, in the normal state the Contingency Dump System is in standby mode. In the event of a "dump" signal the "dump" mode control and action set-points will override the trips and alarms of the standby mode where these set-points are different.

The system is placed in Dump Mode either automatically by a dump demand signal from the cascade control and protection system or can be manually selected either by a push button in the Control Room (Cascade Hall Dump) or from the Plant Control System (Cascade Dump).

A. Contingency Dump System NaF Traps and Buffer Volume.

The NaF traps and buffer volume comprise the passive part of the Contingency Dump System.

The Contingency Dump System pressure is monitored at two positions at the traps and buffer volume. The first position is at the buffer volume upstream of the automatic shut off valve. The second position is downstream of the shut-off valve and monitors the vacuum pump suction line pressure.

The passive dump system operating pressure at the NaF traps and buffer volume is maintained within the range high (H1) to low (L) while the system is in the Standby mode.

Pressure control maintains the pressure at the NaF traps and buffer volume by opening the downstream valve on rising pressure (H1) and closing the valve on falling pressure (L).

A high alarm (H2) at the NaF traps indicates an alarm in the event of the buffer volume pressure rising above its normal operating range in standby mode. A high-high alarm (HH) inhibits the use of the Contingency Dump System by removing the "dump system available" signal to the cascade protection system.

Pressure indication downstream of the automatic valve provides a safety and monitoring function. In the event of a high-high pressure an alarm/trip (HH2) inhibits the use of the active evacuation sequence and will close the valve. The HH2 alarm/trip is active during all standby and dump operating modes of the Contingency Dump System. In "dump" mode the HH2 alarm/trip is overridden in "light gas evacuation" mode only by alarm/trip HH1. Operation of the HH1 alarm/trip will close the valves downstream of the buffer vessel and the active evacuation valve. The low set point of the HH1 trip provides a more rapid response to a fault condition and air ingress at the lower operating pressures of the Contingency Dump System when in light gas evacuation mode.

On dump instruction the Contingency Dump System status is promoted from "Standby" to "Passive Evacuation" and UF_6 and light gas enters the Contingency Dump System from the cascade under the control of the Contingency Dump System. The buffer volume pressure indicator/controller high trip, (H3), is made active overriding the lower trip points to permit light gas passing the NaF traps to fill the buffer volume.

The time T1 is started on dump demand. Time T1 retains the Contingency Dump System in "passive evacuation" for the set period.

B. Contingency Dump System Vacuum Pump/Chemical Trap Set.

On timeout of the timer T1 or a low pressure trip at the cascade header pressure the dump sequence is promoted to "Active Evacuation," the valve down stream of the buffer volume is opened and time T2 is started. During "Active Evacuation" the Contingency Dump System pump module is used to evacuate the accumulating light gases from the buffer volume via the downstream valve. On timeout of timer T2 the Contingency Dump System enters "Light Gas Evacuation" and the cascade is evacuated through the NaF trap bypass line.

A temperature alarm is fitted to the mixed bed trap to provide indication of an excessive carry over of UF_6 gas from the NaF traps and buffer volume when in "Active Evacuation" or directly from the cascade when operating in "Light Gas Evacuation." The temperature alarm provides an alarm function only on excessive UF_6 gas flow at the trap.

The Contingency Dump System interfaces with the Cascade System to provide the Control Room operator with cascade data in the event of a failure in the cascade control PLC.

The following cascade status conditions are monitored by the Contingency Dump System PLC:

A. The position of the cascade dump valve (open/closed)

B. Recipient temperature

C. Cascade header pressure.

The Contingency Dump System monitors the pressure of the cascade header by a single pressure transducer. This pressure transducer is used in conjunction with pressure control at the Contingency Dump System buffer volume to determine the availability of the Contingency Dump System. Contingency Dump System availability is maximized over the whole of the cascade run-down by a two stage monitoring of the cascade header pressure.

Due to the anticipated infrequent use of the Contingency Dump System, its availability is maintained by a regular testing program of both monitoring equipment and valves to ensure that a failure of the Contingency Dump System PLC is revealed.

3.4.8.8 Criticality Safety

3.4.8.8.1 Contigency Dump System NaF Traps

The average enrichment of the UF_6 being dumped from a cascade depends on the product and tails enrichments. Within the ranges of product enrichment up to 5.0 $^{w}/_{o}$ ^{235}U and tails depletion to 0.34 $^{w}/_{o}$ ^{235}U, the average enrichment of the UF_6 being dumped is always less than 1.5 $^{w}/_{o}$ ^{235}U. Based on this, the contingency dump traps are analyzed at an enrichment of 1.5 $^{w}/_{o}$ rather than 6.0 $^{w}/_{o}$. The contingency dump traps are sodium fluoride traps with an outer diameter of approximately 54 cm (21.3 in). Each cascade has an independent contingency dump system that can either discharge to a designated Tails LTTS or to the three NaF Traps for that cascade.

MONK8A (SA, 2001) calculations were carried out first for the three NaF traps at their normal positions with 2.5 cm (0.984 in) of water reflection around the trap body. The calculations considered the cases with and without the associated piping to demonstrate the inconsequential effect of the piping on k_{eff}. The model assumed that adsorbed UF_6 within the trap is wet uranyl fluoride at optimum moderation. The uranium enrichment was 1.5 $^{w}/_{o}$ ^{235}U. The value of k_{eff} obtained was substantially below 0.95. The model represents a UF_6 loading in the entire volume of trap with no credit for the presence of the trap material (NaF). This loading would require many dumps to achieve. Contingency dump traps are thus intrinsically safe by a very large margin.

Considering interaction and movement between the three closely spaced traps, criticality safety is demonstrated with the MONK8A (SA, 2001) calculations. The calculation modeled three touching NaF traps in a close triangular arrangement as the most reactive configuration. For interaction, a 7 L vacuum cleaner approved for cleaning operations was placed in contact with the traps. The vacuum cleaner was filled with wet uranyl fluoride at 6% enrichment and optimum moderation with 2.5 cm of water reflection rather than 1.5% used for the contingency dump system. The resulting K_{eff} is less than the limit of 0.95, demonstrating that the configuration would remain safe as a result of movement due to a seismic or tornado missile event.

The UF_6 containing components for the contingency dump system are located on the second floor of the SBM, and therefore, not impacted by flooding. The safe condition described above for the contingency dump system remains valid under flooded conditions.

3.4.8.8.2 Contingency Dump Vacuum Pump and Chemical Trap Set

The Contingency Dump Vacuum Pump and Trap Set is a system that has similarities to the pump and trap sets in the UF_6 Handling Area (tails evacuation, product, feed, etc). The set is part of the active evacuation of the contingency dump system. The components of the pump/trap set consists of manual isolation valves, a roots vacuum pump (Leybold WSU251), mixed bed chemical trap, a rotary vane vacuum pump (Oerlikon Leybold TRIVAC D40BCS), an Al_2O_3 oil adsorption filter and an exhaust filter with oil return. The items on the Pump and Trap Set are safe-by-design individually. The Pump and Trap Set as a whole is safe-by-design by physical arrangement as demonstrated in a nuclear criticality safety evaluation through comparison to a bounding calculation performed for the product vent vacuum pump/chemical trap set described in Section 3.4.4.8.3.

3.4.8.8.3 Assay Dump to a Tails Cylinder

Upon activation of the contingency dump, the preferred evacuation route is to the tails cylinders. The contingency dump removes all UF_6 from the cascade halls thus mixing the feed, tails, and product material to have an upper-limit average enrichment of 1.5%.

The components involved in the removal of UF_6 are the associated piping, low temperature take-off stations (LTTS), and 48Y cylinders.

The model conservatively assumed that only one LTTS was available and all material was evacuated into that tails cylinder. Additionally, the material was conservatively assumed to be greater than the quantity within the cascades and associated piping. The MONK8A (SA, 2001) model provides a bounding analysis consisting of a generic geometry to create conservative conditions. This material from the cascades was assumed to be optimally moderated at an H/U ratio of 7 as a sphere. This sphere was further encased by unmoderated UF_6 at a maximum theoretical density to increase the reflection of the system. To account for spurious reflection, a 2.5 cm of water wrapped the outer sphere. The system did not consider neutron interaction due to the location and isolation of the cylinders within the LTTS. The MONK8A (SA, 2001) result was well within the sub-critical limit of 0.95, based on an average enrichment of 1.5% as for the Contingency Dump System.