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Integrated Safety Analysis Summary

Revision 4, April 2005
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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).

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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.

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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.

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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.

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3.0 APPLICABLE 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 (NRC, 2002) 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 (NRC, 2002), 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		
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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)

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3.0.1 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, Part 70, Domestic Licensing of Special Nuclear Material, 2003.

NRC, 2002. Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, NUREG-1520, U.S. Nuclear Regulatory Commission, March 2002.

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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 (NRC, 2002). 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 ISA uses a hazard analysis method to identify the hazards which are relevant for each system or facility. 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 Technical Services Building systems. This method is consistent with the guidance provided in NUREG-1513 (NRC, 2001) and NUREG-1520 (NRC, 2002). 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
- On-site Use of Natural Gas
- 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 Process 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 (NRC, 2001). 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 Technical Services Building (TSB) 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 (NRC, 2001) and NUREG-1520 (NRC, 2002).

To validate the Urenco HAZOPs, the ISA Team performed the following tasks:

- The Urenco process engineer described the salient points of the process system covered by the HAZOP being validated.
- The ISA Team divided the process "Nodes" into reasonable functional blocks.
- The process engineer described the salient points of the items covered by the "Node" being reviewed.
- The ISA Team reviewed the "Guideword" used in the Urenco HAZOP to determine if the HAZOP is likely to identify all credible hazards. A representative list of the guidewords used by the ISA Team is provided in Table 3.1-1, HAZOP Guidewords, to ensure that a complete assessment was performed.
- The ISA Team Leader introduced each Guideword being considered in the ISA HAZOP and the team reviewed and considered the potential hazards.
- 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.
- For each hazard, the ISA Team considered existing safeguards designed to prevent the hazard from occurring.
- For each hazard, the ISA Team also considered any existing design features that could mitigate/reduce the consequences.

- The Urenco HAZOP was modified to reflect the ISA Team's input in the areas of hazards, causes, consequences, safeguards and mitigating features.
- 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).
- When all of the Guidewords had been considered for a particular node, the ISA Team applied the same process and guidewords to the next node until the entire process system was completed.

The same process as above was followed for the TSB 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 Risk Matrix Development

3.1.1.3.1 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.

3.1.1.3.2 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 (NRC, 2002). The definition of "highly unlikely" is taken from NUREG-1520 (NRC, 2002). 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 enrichment, 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
- ETC4009723, Criticality Assessment of Passive Safe-by-Design Components, Cylinder Preparation 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 (NRC, 2002). 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.

3.1.1.3.3 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.

3.1.1.4 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 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 (NRC, 2002). 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

ISA Team Member	Experience and Qualifications
	with responsibility for the NEF for Urenco. Degree in Physics.
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.

Classified ISA Team Member	Experience and Qualifications
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.
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 – hydrogen fluoride (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-8.3-1997 Criticality Accident Alarm System (ANSI, 1997) as modified by Regulatory Guide 3.71, Nuclear Criticality Safety Standards Fuels and Material Facilities (NRC, 1998).

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 (ANSI, 1997), 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 emergency power and is designed to remain operational during credible events or conditions, including fire, explosion, corrosive atmosphere, or seismic shock (equivalent to the site-specific design-basis earthquake or the equivalent value specified by the uniform building code).

Whenever the CAAS is not functional, compensatory measures, such as limiting access and restricting SNM movement, will be implemented. Should the CAAS coverage be lost and not restored within a specified number of hours, the operations will be rendered safe (by shutdown and quarantine) if necessary. Onsite guidance is provided and is 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.

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 "item relied on for safety" (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. IEEE-383 (ANSI/IEEE, 1974) fire resistant cabling shall be used for all uranic material system power, instrumentation and control circuits. 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 absorbers are not needed and are not used at the NEF.

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-279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (IEEE, 1971), 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.

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 (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

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

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

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NRC, 2002. Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility, NUREG-1520, U.S. Nuclear Regulatory Commission, March 2002.

TABLES

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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	
No Flow			
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

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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) For the worker (elsewhere in room), except the worker (local), Chemical Dose (CD) > AEGL-3 For worker (local), CD > AEGL-3 for HF CD > * 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) For the worker (elsewhere in room), except the worker (local), AEGL-2 < CD≤ AEGL-3 For the worker (local), AEGL-2 < CD ≤ AEGL-3 for HF ** < CD ≤ * 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:

*NUREG-1391 threshold value for intake of soluble U resulting in permanent renal failure

**NUREG-1391 threshold value for intake of soluble U resulting in no significant acute effects to an exposed individual

Table 3.1-4 Chemical Dose Information

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	High Consequence (Category 3)	**Intermediate Consequence (Category 2)**
Worker (local)	> 40 mg U intake > 139 mg HF/m^3	> 10 mg U intake > 78 mg HF/m^3
Worker (elsewhere in room)	> 146 mg U/m^3 > 139 mg HF/m^3	> 19 mg U/m^3 > 78 mg HF/m^3
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

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	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

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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

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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

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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}	

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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. 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 (NRC, 1981). 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

- 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 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, 1998) 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 snow loading of 156 kg/m^2 (32 lb/ft^2).

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 systems in Hobbs and 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., winds, 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 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, 1998) 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 snow loading of 156 kg/m^2 (32 lb/ft^2).

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 1×10^{-8} cm/s (4×10^{-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 ft^3/s) measured June 10, 1972. All other historical maximum measurements are below 2.0 m^3/s (70 ft^3/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 subsurface borings and 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

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. This will be accomplished by designing the parapets to a height which will preclude significant ponding on the roof. As an alternative, the parapets can be provided with scuppers that are designed to preclude significant roof ponding during the local intense PMP.

Local site runoff will be determined for the local plant site drainage area. Maximum ponding depths around the main plant structures will be determined using final site topography. The potential for water intrusion into critical plant areas will be precluded by final site grading.

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 (2.1 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:

$$A = LW + 4H(L + W) + 12.57 H^2$$

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

L = 534 m (1,752 ft), W = 534 m (1,752 ft), H = 13 m (43 ft)

The total attractive area is therefore equal to 0.34 km^2 (0.13 mi^2). Consequently, the lightning strike frequency computed using Marshall's methodology is given as 1.36 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 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. 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 1×10^{-8} cm/s (4×10^{-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 ft^3/s) measured June 10, 1972. All other historical maximum measurements are below 2.0 m^3/s (70 ft^3/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 subsurface borings and 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 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. No samples could be collected for water quality analysis at the time of well construction. One groundwater sample has since been collected due to the limited groundwater occurrence.

The land surface elevation was surveyed at each of the nine 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 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.

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, three monitoring wells were installed on the NEF site in September 2003 with screened intervals within this siltstone unit. These wells are 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, have been drilled and installed on the NEF site as shown on (Figure 3.2-5), and several water quality samples have been obtained. 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 +1,033 and +1,045 m (+3,390 and +3,430 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 NEF site and adjacent site 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.

The NEF site 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. Figure 3.2-16, Site Soils Map, shows the soil map for the NEF site (USDA, 1974). The legend for that map lists each of the soils present at

the NEF site describing them and along with their unified soil classification designations (ASTM, 1993).

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 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 borings done for engineering purposes ranged from about 3.6 to 9.1 m (12 to 30 ft).

The dry density of the clay ranges from 1.86 to 2.32 g/cm^3 (116 to 145 lb/ft^3), averaging 2.11 g/cm^3 (132 lb/ft^3). The red, reddish-brown or purple silty clays range in moisture content from 2.5% to 25%, averaging 8% 12% for most samples. Liquid limits for the clays range from 35% to 55% with plasticity indices ranging from 24 to 38. Percent passing the #200 sieve for the clays ranges from 87% to 99.8%.

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 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).

A geotechnical investigation of the NEF site conducted in September 2003 consisted of 5 widely-spaced test borings that extended to depths of about 12 to 30.5 m (40 to 100 ft) using a hollow-stem auger and split-spoon sampling. Based on the boring results, up to 0.6 m (2 ft) of loose eolian sand underlain by dense to very dense, fine- to medium-grained sand and silty sand of the Gatuña/Antlers Formation was encountered. These sands are locally cemented with caliche deposits. Beneath the Gatuña/Antlers Formation is the Chinle claystone, a very hard highly plastic clay, which was encountered at depths of about 10.7 to 12.2 m (35 to 40 ft). One boring extended to 30.5 m (100 ft) deep and ended in the Chinle Formation. Blow-count N-values for about the top 7.6 m (25 ft) of sand and gravel ranged from about 20 to 76. Beneath that horizon the unit becomes denser or contains gravel to the extent that useful blow counts are not obtained. Where caliche cements the sand and gravel, N-values of over 60 are typical. Standard N-values were not available for samples in the underlying clay due to its hardness causing blow counts to range upwards of 100.

For samples from the shallow sand and gravel unit, California Bearing Ratio values of 10.5 and 34.4 were obtained along with a maximum dry density value of 1.97 g/cm^3 (123 lbs/ft^3). Fines in this material were generally non-plastic with 17% to 31% of samples finer than 200 sieve size. Clay samples had relatively high liquid limits of 50% to 60% and plastic limits of 18% to 23%, suggesting high silt content.

Footings bearing in the firm and dense sandy soils below the upper loose eolian soils are estimated to have an allowable bearing pressure of 34,177 kg/m^2 (7,000 lb/ft^3).

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 CO_2 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, M_d, that in turn approximate Local Magnitude, M_L. 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].

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

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 Design Earthquake. 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/s^2 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/s^2 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, m_{bLg}, and for Moment magnitude, M_O. 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 (EPRI, 1988) 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, M_X, 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 M_X 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, M_X.

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. 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 S_s and S_l 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 3.2-32. Vertical component earthquake response spectra are recommended in NRC Regulatory Guide 1.60 (NRC, 1973) to be determined as a function of frequency. Table 3.2-31, Regulatory Guide 1.60 Ratio of Vertical to Horizontal Component Design Response Spectra, summarizes the ratio of vertical and horizontal component earthquake response spectra.

The vertical component 10,000-year response spectrum was determined using the formulation shown in Table 3.2-31.

Numerical values for the 10,000-year horizontal and vertical design response spectra for five percent damping are listed in Table 3.2-32, Horizontal Response Spectrum for the 10,000-Year Design Earthquake, and Table 3.2-33, Vertical Response Spectrum for the 10,000-Year Design 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 (NRC, 2002), 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 (DOE, 2002) and ASCE Standard Seismic Design Criteria (ASCE, 2003) was considered along with the results of the seismic portion of the ISA and the site-specific probabilistic seismic hazard analysis performed for the NEF site.

The DOE and ASCE standards outline a methodology to demonstrate compliance to a target performance goal of 1.0 E-5 annual probability by designing to a seismic hazard of 1.0 E-4 annual probability. The difference between the design level and the performance target is accounted for in the detailed design process by confirmatory calculations.

Based on these approaches, the DBE for the NEF has been selected as the 10,000-year (1.0 E-4 mean annual probability) earthquake. For the NEF, following the DOE or ASCE approach provides a risk reduction ratio of design to target performance of 10 (1.0 E-4/1.0 E-5). This DBE will be used in the detailed design process to demonstrate compliance with the overall ISA performance requirements. This will be accomplished by confirmatory seismic performance calculations for the seismic Items Relied on for Safety (IROFS) during detailed design. The DOE and ASCE standards address design and evaluation of structures, systems, and components (SSCs). The equivalents of SSCs for the NEF are considered to be the IROFS and the items that may affect the function of IROFS. The objective of the NEF seismic design approach is to demonstrate that use of this DBE achieves a likelihood of unacceptable performance of less than approximately 1.0 E-5 per year, by introducing sufficient design safety margins, i.e., conservatism, during the design process to allow for demonstration of compliance to the target performance goal. The DOE and ASCE standards implement this objective using slightly different methodologies with the same end result, i.e., demonstration of compliance to the target performance goal.

In the DOE approach, the deterministic seismic evaluation and acceptance criteria are structured to achieve less than a 10% probability of unacceptable performance for a SSC subjected to the scaled design/evaluation basis earthquake (SDBE). The SDBE is defined in the DOE approach as the product of the DBE times a factor of 1.5 and a scale factor, which is a function of the slope of the seismic hazard curve.

The ASCE approach is based on achieving the target performance goal annual frequencies by incorporating sufficient conservatism in the seismic demand and structural capacity evaluations to achieve both of the following:

- Less than about a 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 method is based on achieving both of the above probability goals, which represent two points on the underlying fragility curve. Meeting these two probability goals allows the target performance probabilities to be achieved with less possibility of non-conservatism. The resulting nominal factors of safety against conditional probability of failure are 1.0 and 1.5, respectively, for the above two goals.

The actual seismic design detailed approach for NEF will be based on the DOE or ASCE method and finalized prior to detailed design. The safety margins will be representative of those discussed above and described in more detail in the DOE and ASCE standards.

The difference between the mean annual probabilities for design (1.0 E-4) and performance (1.0 E-5) is achieved through conservatism in the design (factors of safety), elasticity in the structures, and conservatism in the evaluation of the design.

The design response spectra, horizontal and vertical, are based on the 10,000-year uniform hazard response spectra described in Section 3.2.6.4.3, Uniform Hazard Response Spectra. The soil amplification factors described in Section 3.2.6.4.3 will be verified during the detailed design phase of the NEF project.

3.2.7 Stability of Subsurface Materials

A geotechnical investigation of the site conducted in September 2003 consisted of 5 widely-spaced test borings that extended to depths of about 12 to 30.5 m (40 to 100 ft) using a hollow-stem auger and split-spoon sampling. Based on the boring results, up to 0.6 m (2 ft) of loose eolian sand underlain by dense to very dense, fine- to medium-grained sand and silty sand of the Gatuña/Antlers Formation was encountered. These sands are locally cemented with caliche deposits. Beneath the Gatuña/Antlers Formation is the Chinle claystone, a very hard highly plastic clay, which was encountered at depths of about 10.7 to 12.2 m (35 to 40 ft). One boring extended to 30.5 m (100 ft) deep and ended in the Chinle Formation. Blow-count N-values for about the top 7.6 m (25 ft) of sand and gravel ranged from about 20 to 76. Beneath that horizon the unit becomes denser or contains gravel to the extent that useful blow counts are not obtained. Where caliche cements the sand and gravel, N-values of over 60 are typical. Standard N-values were not available for samples in the underlying clay due to its hardness causing blow counts to range upwards of 100.

For samples from the shallow sand and gravel unit, California Bearing Ratio values of 10.5 and 34.4 were obtained along with a maximum dry density value of 1.97 g/cm^3 (123 lbs/ft^3). Fines in this material were generally non-plastic with 17% to 31% of samples finer than 200 sieve size. Clay samples had relatively high liquid limits of 50% to 60% and plastic limits of 18% to 23%, suggesting high silt content.

Footings bearing in the firm and dense sandy soils below the upper loose eolian soils are estimated to have an allowable bearing pressure of 34,177 kg/m^2 (7,000 lbs/ft^3).

The five borings are not sufficient to adequately define subsurface conditions for final design purposes, but they are acceptable for judging the feasibility of developing the site. Assuming that the borings are generally representative of subsurface conditions, the site is considered acceptable for the facility features supported on a system of shallow foundations.

The surface deposits silty sands will be removed to expose the more firm soil structures. In this case, footings bearing in the firm and dense sandy soils below the upper, loose eolian soils can be designed for an allowable bearing pressure of 34,000 kg/m^2 (7,000 lb/ft^2). Due consideration will be given to settlement and differential settlement during final design. Final design details will be based on a more comprehensive geotechnical investigation to be undertaken when additional project details are available.

3.2.7.1 Liquefaction Susceptibility

Liquefaction potential is greatest where the groundwater level is shallow; and submerged, loose fine sands occur within a depth of about 15 m (50 ft). Liquefaction potential decreases as grain size and clay and gravel content increase.

The soils at the site are dense to very dense. Groundwater was encountered in the site soil borings drilled to a depth of more than 30 m (100 ft) below the ground surface. The nature of the soils and the absence of groundwater near the surface would make the potential for liquefaction remote.

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3.2.8 References

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TABLES

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

Topic	Area				
	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

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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
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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)

Table 3.2-4 Agriculture Census, Crop, and Livestock Information
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Information	County	
	Lea (New Mexico)	**Andrews (Texas)**
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
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	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)

Local Climatological Data Annual Summary with Comparative Data for Midland-Odessa, Texas, National Oceanic and Atmospheric Administration, 2002.

Table 3.2-6 Roswell, New Mexico, Wind Data
1961-1990
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	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
Page 1 of 1

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
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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
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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
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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	260	61.5	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
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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
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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
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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
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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

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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

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

Table 3.2-17 Midland-Odessa, Texas, Snowfall Data
1961-1990
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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)

Local Climatological Data Annual Summary with Comparative Data for Midland-Odessa, Texas, National Oceanic and Atmospheric Administration, 2002.

Table 3.2-18 Roswell, New Mexico, Snowfall Data
1961-1990
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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
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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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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
1976	6	15	-102.34	31.56			0.00	M	120.0	74.6	NMTR

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	(mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	(mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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
1992	1	4	-103.19	32.30			1.50	M	17.8	11.0	NMTR
92	1	7	-103.19	32.30			2.40	M	17.8	11.0	NMTR
992	1	9	-103.19	32.30			2.80	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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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

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

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal Depth[1] (mi)	MAG[2]	MAG Type[3]	Epicentral Distance (km)	Epicentral Distance (mi)	Data Sources[4]
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
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:

[1] 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 3.2-21 Earthquakes of Magnitude 3.0 and Greater Within 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 3.2-21 Earthquakes of Magnitude 3.0 and Greater Within 322 km (200 mi) Radius of the NEF Site

Year	Month	Day	Longitude (°W)	Latitude (°N)	Focal Depth[1] (km)	Focal 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:

1 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

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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, 1988	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

Page 1 of 1

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 Regulatory Guide 1.60 Ratio of Vertical to Horizontal Component Design Response Spectra

Page 1 of 1

Period range	**Ratio Vertical/Horizontal**
> 4.0 s (< 0.25 Hz)	2/3
< 0.29 s (> 3.5 Hz)	1.0
Between 0.29 and 4.0 s	Varies between 2/3 and 1.0

Table 3.2-32 Horizontal Response Spectrum for the 10,000-Year Design Earthquake

Soil Class C			
Period s	**psrv cm/s**	**Sa (g)**	**SD mm**
0.020	0.472	0.151	0.015
0.030	0.715	0.151	0.034
0.040	1.420	0.227	0.090
0.100	5.473	0.351	0.871
0.200	10.809	0.346	3.440
0.400	10.809	0.173	6.881
1.000	10.809	0.069	17.202
2.000	5.404	0.017	17.202

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

Table 3.2-33 Vertical Response Spectrum for the 10,000-Year Design Earthquake

Soil Class C			
Period s	**psrv cm/s**	**Sa (g)**	**SD mm**
0.020	0.472	0.151	0.015
0.030	0.715	0.151	0.034
0.040	1.420	0.227	0.090
0.100	5.473	0.351	0.871
0.200	7.242	0.232	2.305
0.400	7.242	0.116	4.610
1.000	7.242	0.046	11.526
2.000	3.621	0.012	11.526

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

FIGURES

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FIGURES

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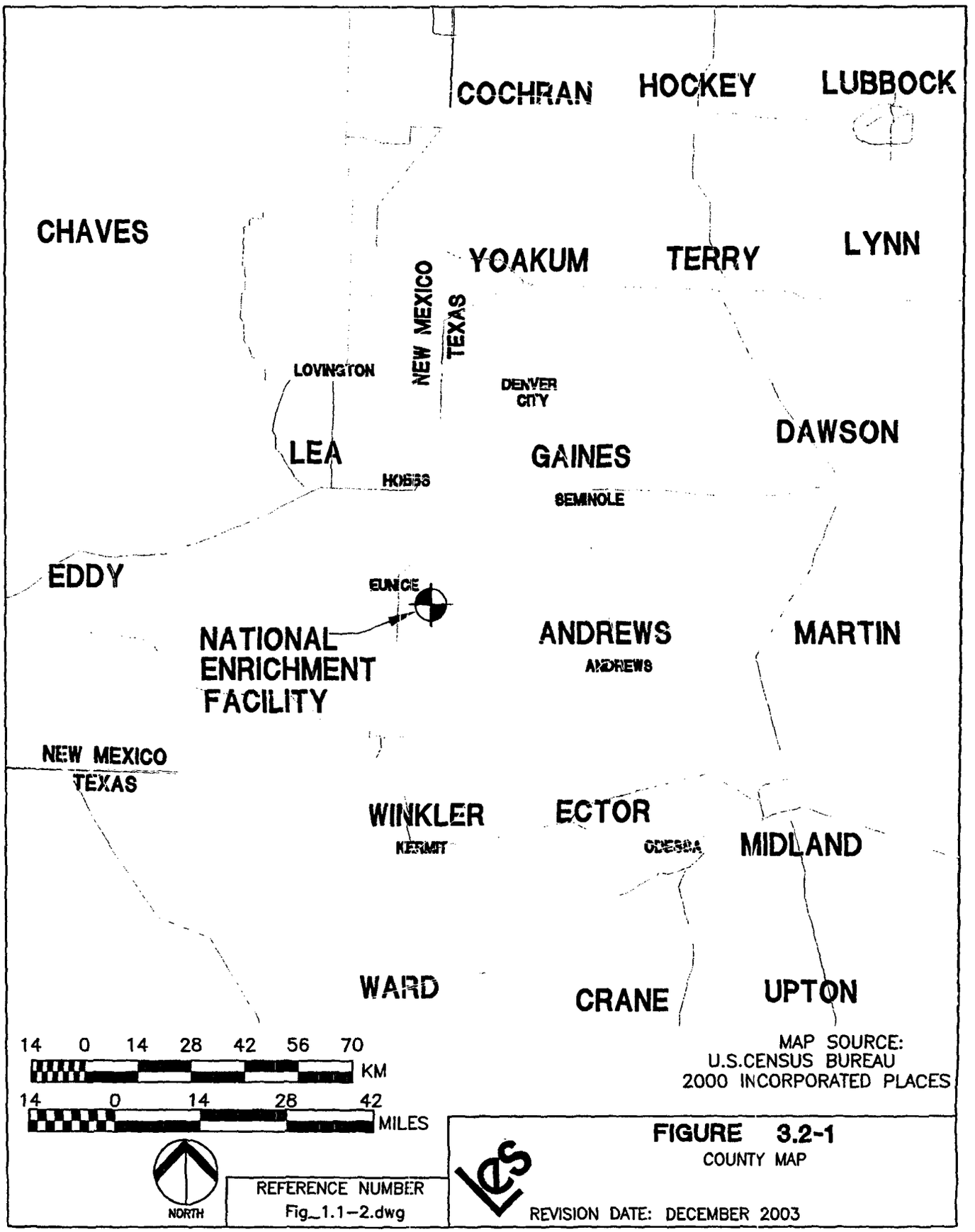
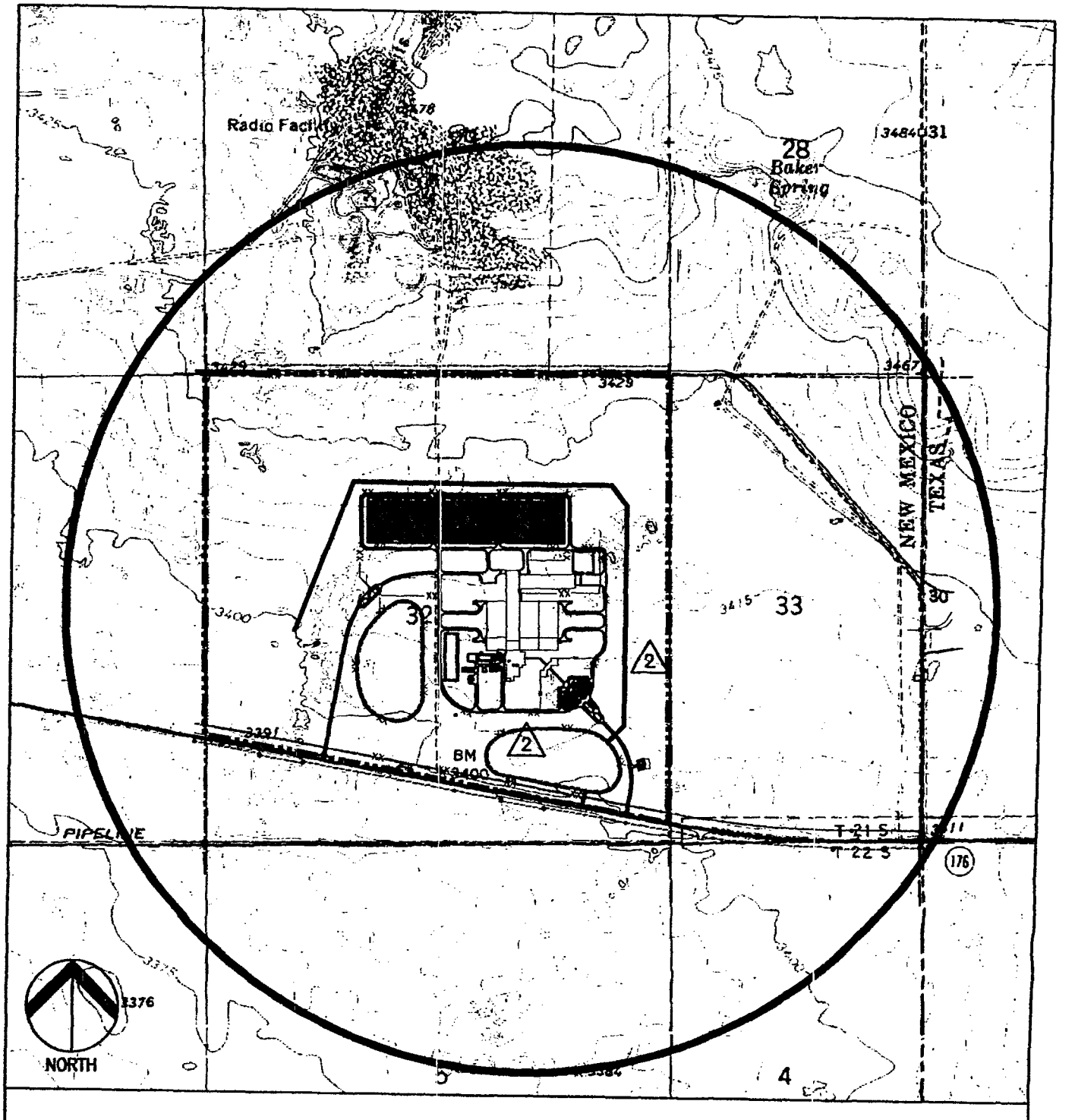


FIGURE 3.2-1
COUNTY MAP



1000 0 1000 2000 3000 FEET

300 0 300 600 900 METERS

MAP SOURCE:
USGS 7.5 MINUTE
EUNICE NE QUADRANGLE
TEX.–N. MEX. 1:24000

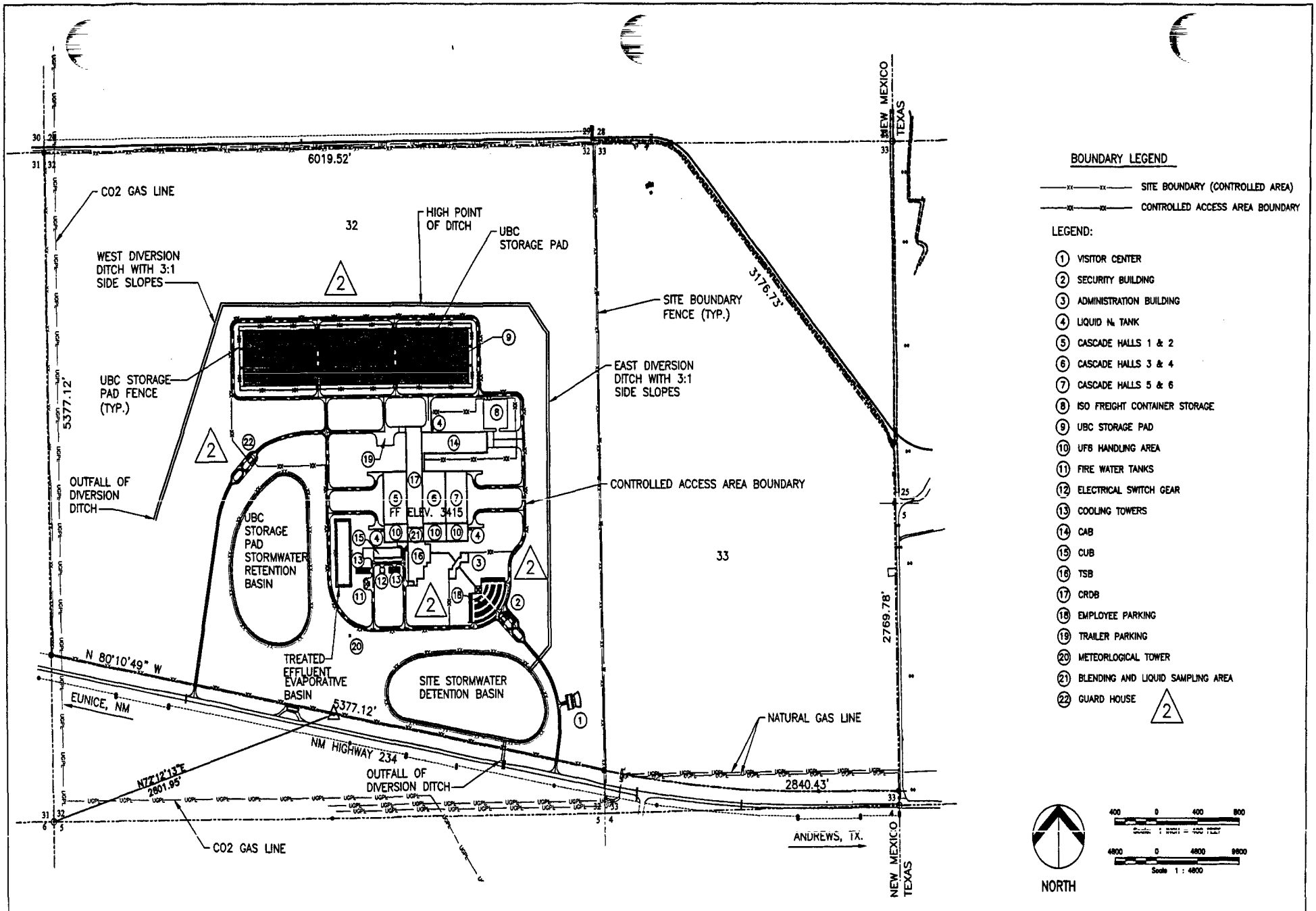
CONTOUR INTERVAL:
5 FEET

LOCKWOOD GREENE
ENGINEERING & CONSTRUCTION

REFERENCE NUMBER
Figure_3.2–2.dwg

FIGURE 3.2-2
PLOT PLAN
(1 MILE RADIUS)

REVISION 2 DATE: JULY 2004



BOUNDARY LEGEND

SITE BOUNDARY (CONTROLLED AREA)

CONTROLLED ACCESS AREA BOUNDARY

LEGEND:

1. VISITOR CENTER
2. SECURITY BUILDING
3. ADMINISTRATION BUILDING
4. LIQUID N_2 TANK
5. CASCADE HALLS 1 & 2
6. CASCADE HALLS 3 & 4
7. CASCADE HALLS 5 & 6
8. ISO FREIGHT CONTAINER STORAGE
9. UBC STORAGE PAD
10. UF6 HANDLING AREA
11. FIRE WATER TANKS
12. ELECTRICAL SWITCH GEAR
13. COOLING TOWERS
14. CAB
15. CUB
16. TSB
17. CRDB
18. EMPLOYEE PARKING
19. TRAILER PARKING
20. METEORLOGICAL TOWER
21. BLENDING AND LIQUID SAMPLING AREA
22. GUARD HOUSE

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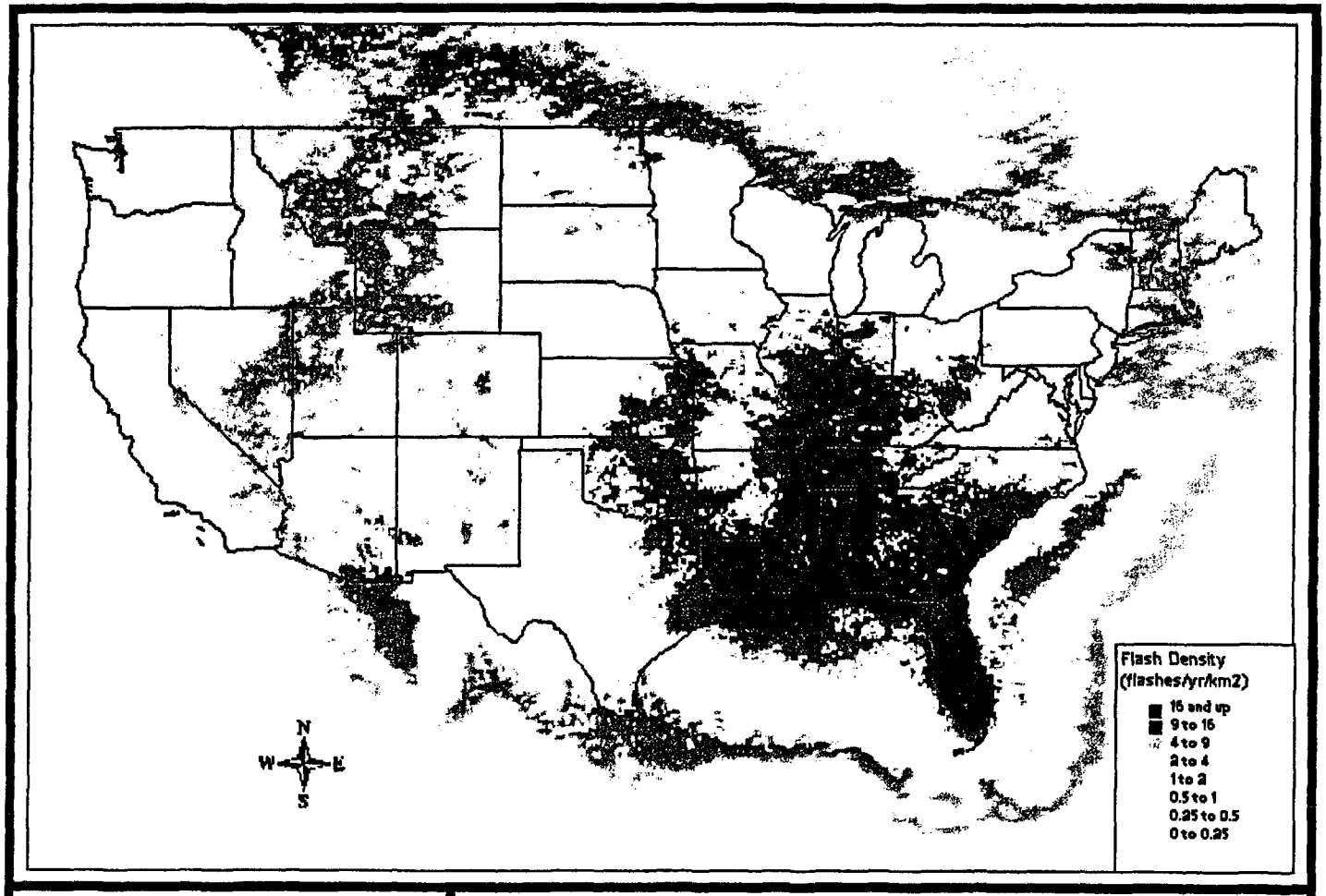
REFERENCE NUMBER c0000001.dwg

FIGURE 3.2-3

SITE PLAN

REVISION 2 DATE: JULY 2004



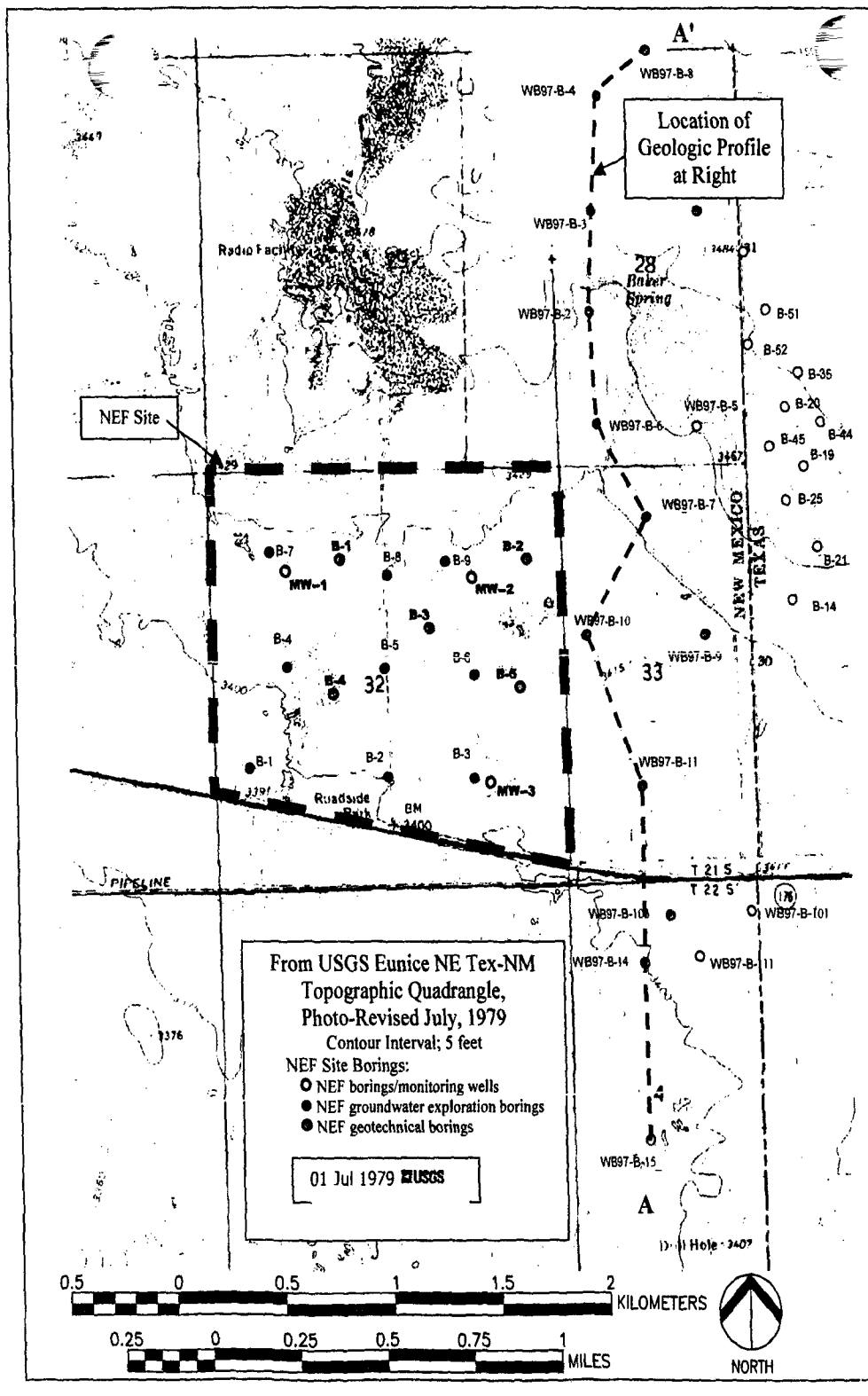
1996-2000 FLASH DENSITY MAP

(NWS, 2003)

REFERENCE NUMBER
Figu 2-4.dwg

FIGURE 3.2-4
AVERAGE LIGHTNING FLASH DENSITY

REVISION DATE: DECEMBER 2003



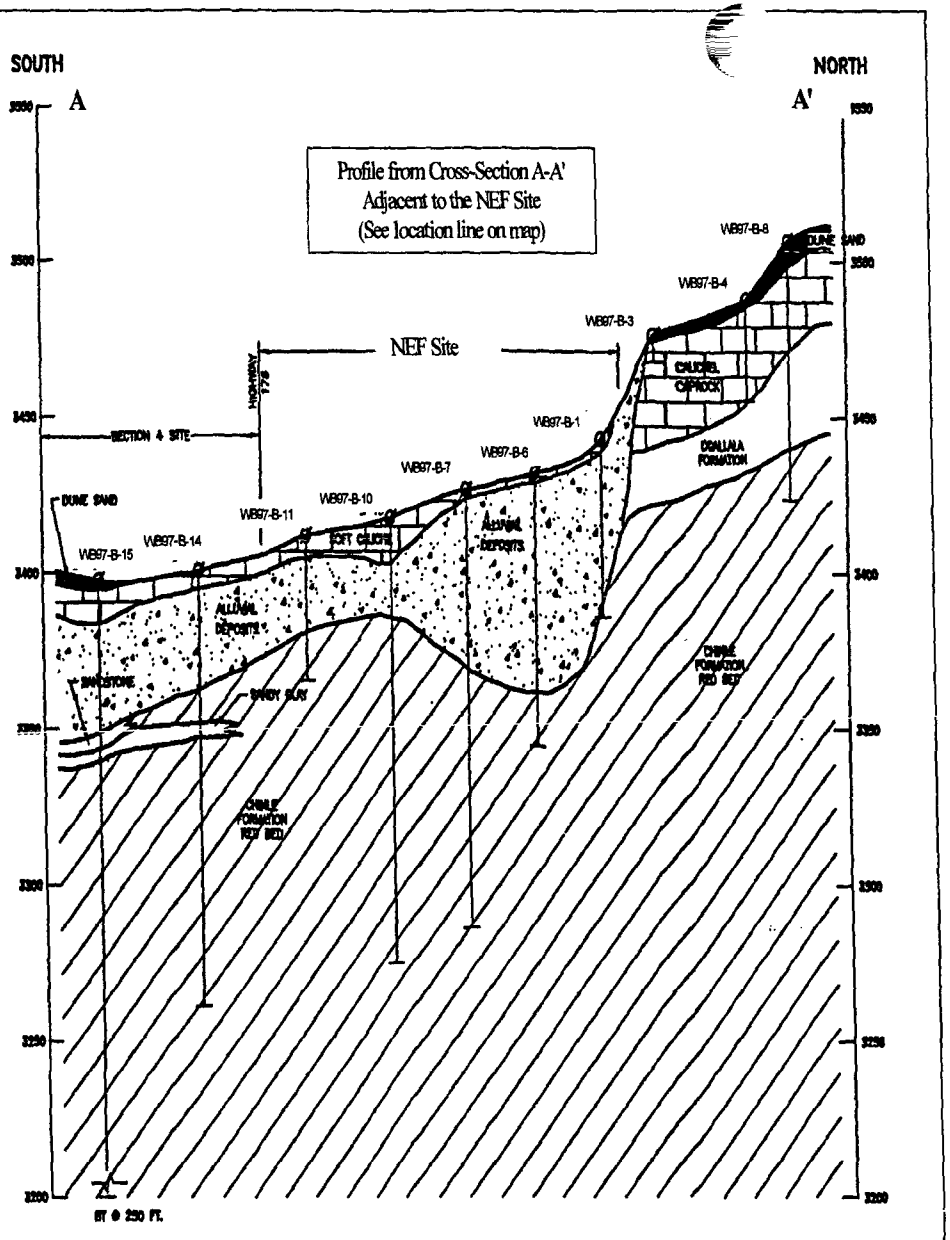
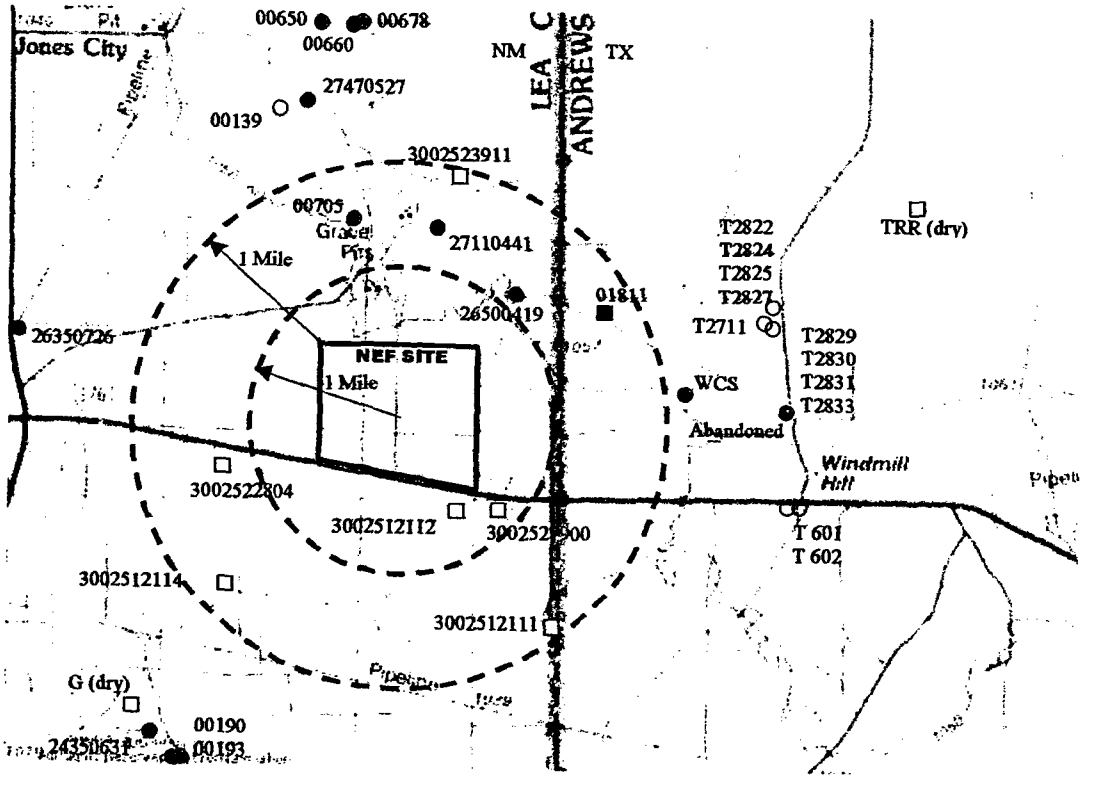


FIGURE 3.2-5
SITE BORING PLAN AND PROFILE

REFERENCE NUMBER
Figure 3.2-5.dwg

REVISION DATE: DECEMBER 2003

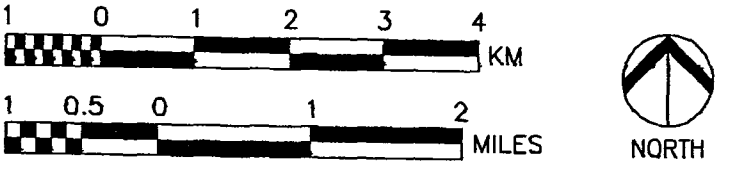


Water Wells

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

Oil Wells

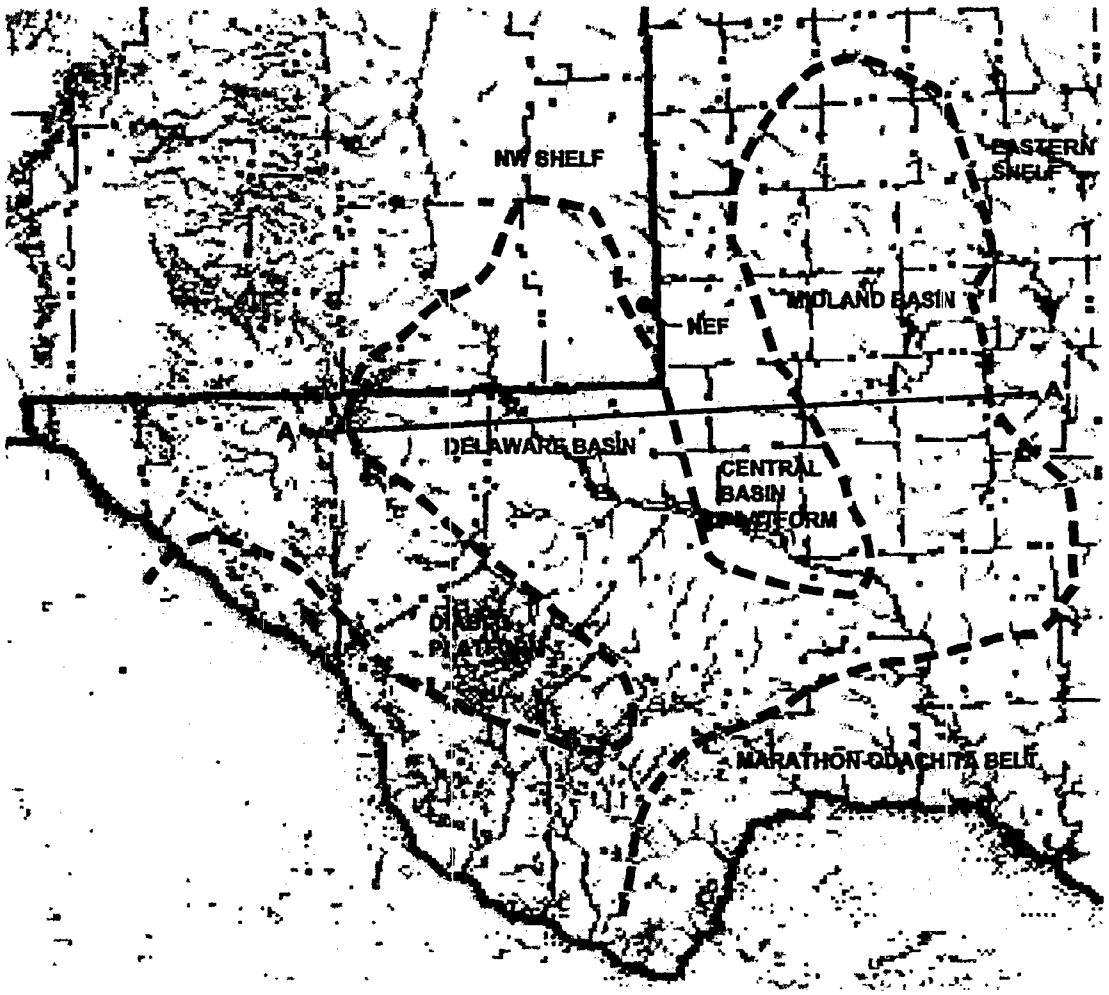
- ■ □ Open symbol represents dry, plugged and/or abandoned hole



REFERENCE NUMBER
Figure 3.2-6.dwg

FIGURE 3.2-6
WATER AND OIL WELLS
IN THE VICINITY OF THE NEF SITE

REVISION DATE: DECEMBER 2003



Permian Basin Geologic Profile

(Generalized from UTPB, 2003)

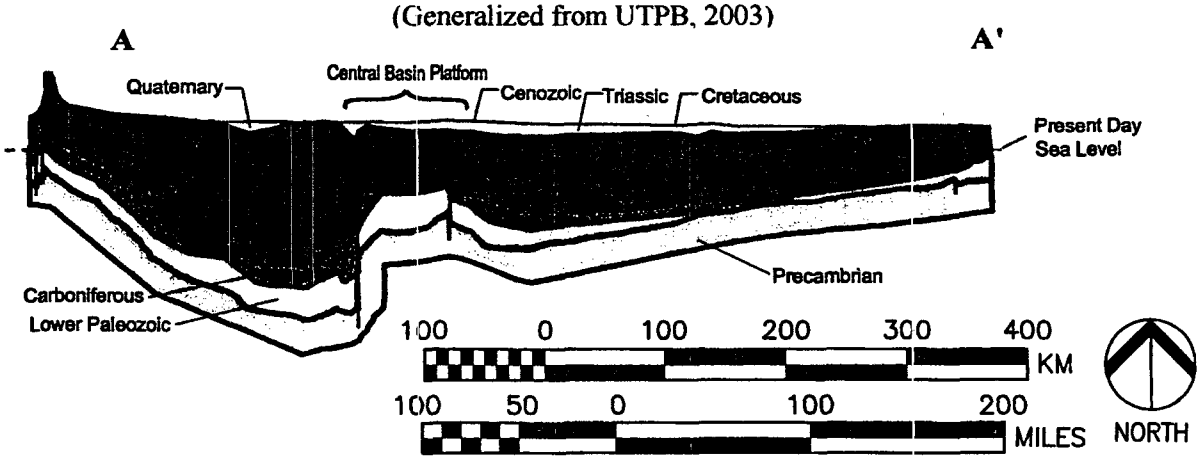
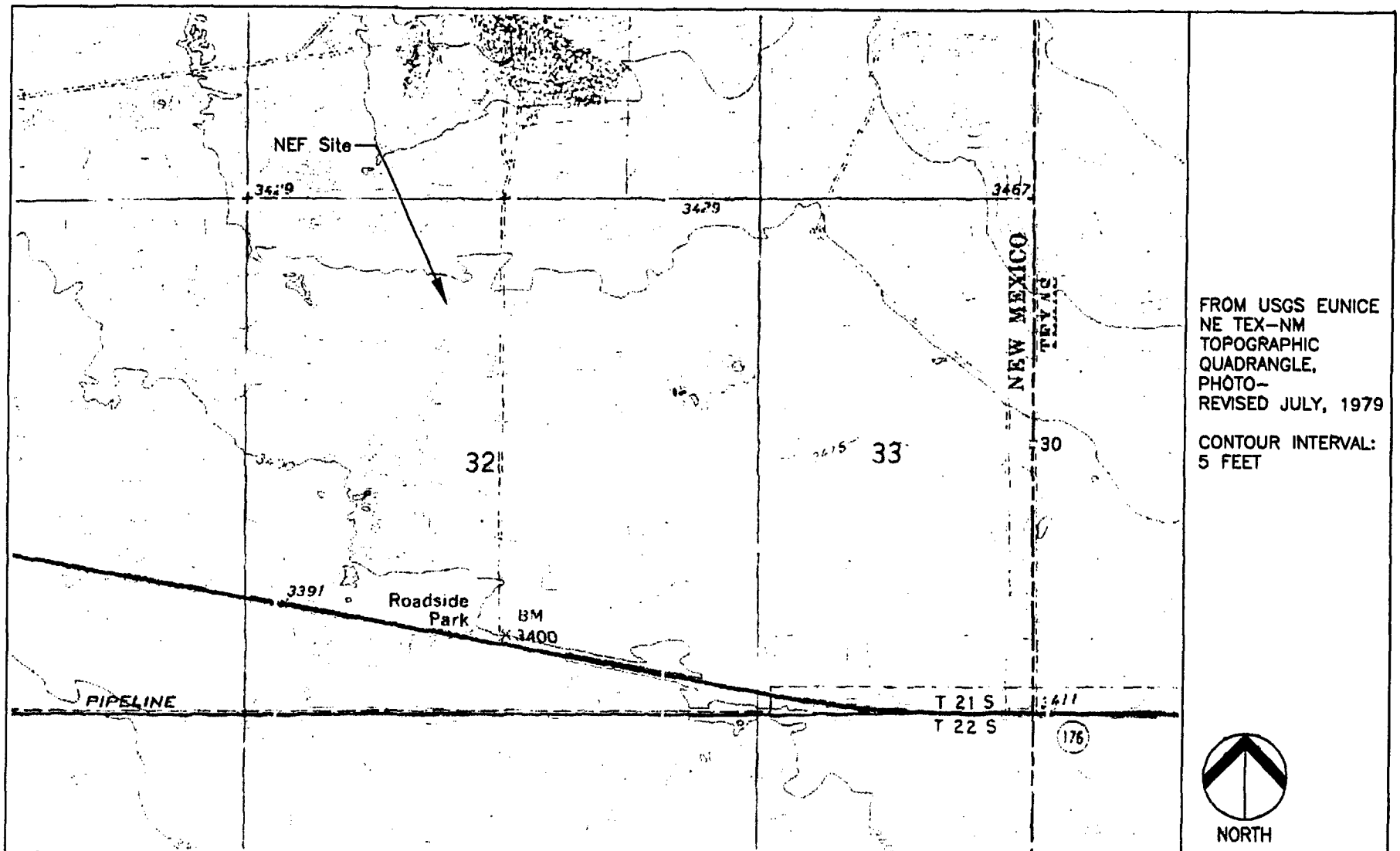


FIGURE 3.2-7

PERMIAN BASIN GEOLOGIC STRUCTURES AND PROFILE

REFERENCE NUMBER
1Figures 3.2.dwg

REVISION DATE: DECEMBER 2003



FROM USGS EUNICE NE TEX–NM TOPOGRAPHIC QUADRANGLE, PHOTO–REVISED JULY, 1979

CONTOUR INTERVAL: 5 FEET

0.25 0 0.25 0.5 0.75 1 MILES

Modif[illegible] [illegible]rom: http://mrdata.usgs.gov.

REFERENCE NUMBER
Figure [illegible]3.dwg

FIGURE 3.2-8
SITE TOPOGRAPHY

REVISION DATE: DECEMBER 2003

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 loam, 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.

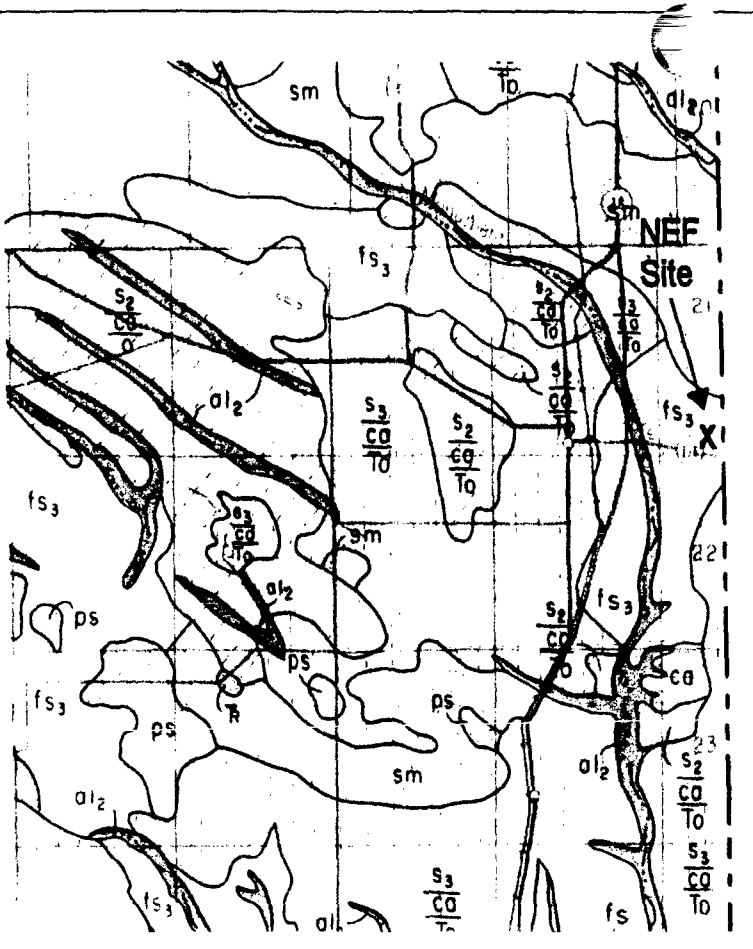
s_2/ca/To — MODERATELY THICK SAND ON CALICHE ON OGALLALA FORMATION. Sand 1 to 3 ft thick. Surface layers noncalcareous over reddish loam. Local sand mounds. Ground favored for farming. Boundaries approximate.

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.

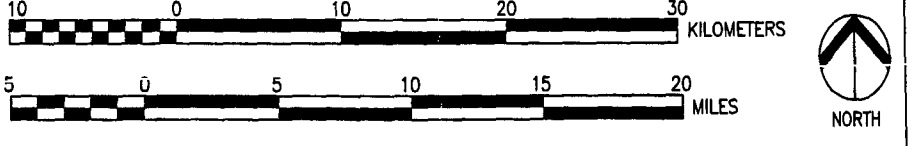
sm — LOOSE SAND IN MOUNDS. Coppice dunes, commonly 3 to 7 ft high and 25 to 50 ft in diameter, generally elongated north of east but a local exception lies east of Columbus where elongation is south of east. Age is Holocene. Boundaries fairly accurate.

ps — SANDY LAKE OR PLAYA DEPOSITS. Gypsiferous deposits labeled ps_3.

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; Rs Triassic Santa Rosa Sandstone). Many small areas omitted, indicated boundaries are approximate. R Triassic undifferentiated.



REFERENCE: (NMIMT, 1977)

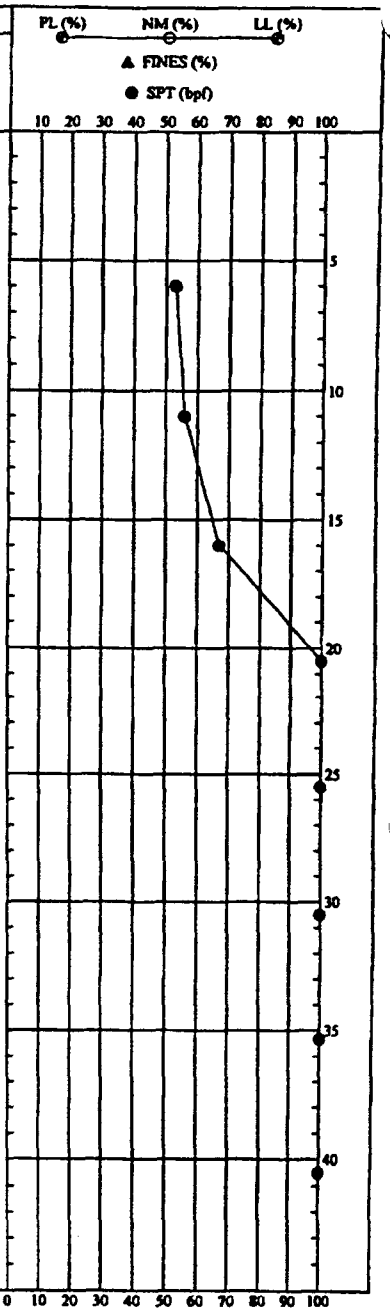


REFERENCE NUMBER
Figure 3.2-9.dwg

FIGURE 3.2-9
SURFICIAL GEOLOGIC MAP OF THE NEF SITE AREA

REVISION DATE: DECEMBER 2003

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"
0	REDDISH BROWN, DRY, SILTY FINE SAND WITH SOME FINE ROOTS - EOLIAN		3423.4			
	VERY DENSE, REDDISH BROWN, DRY, SILTY FINE TO MEDIUM SAND					
5			3418.4	SPT-1		15-25-28
10			3413.4	SPT-2		21-30-26
15	VERY DENSE, DARK RED, DRY, FINE TO MEDIUM SILTY FINE TO MEDIUM SAND WITH CLASTS OF CEMENTED SAND		3408.4	SPT-3		15-30-37
20	VERY DENSE, LIGHT REDDISH YELLOW, DRY, SILTY FINE TO MEDIUM SAND WITH CLASTS OF CEMENTED SAND		3403.4	SPT-4		50/6"
				UD-1		1.0-2.0
25			3398.4	SPT-5		50/6"
30			3393.4	SPT-6		50/6"
35	VERY DENSE, LIGHT REDDISH YELLOW, SILTY FINE TO COARSE SAND WITH SOME SUBANGULAR TO ROUNDED FINE GRAVEL		3388.4	SPT-7		50/4"
40	VERY HARD, DARK RED, DRY, HIGH PLASTICITY CLAY BORING TERMINATED 40.5'		3383.4	SPT-8		50/6"
45			3378.4			



SOIL 3045031049_01.GPJ LAW OFBB.GDT 10/2/03

REMARKS STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/9/2003

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 9, 2003 **BORING NO.:** B-1

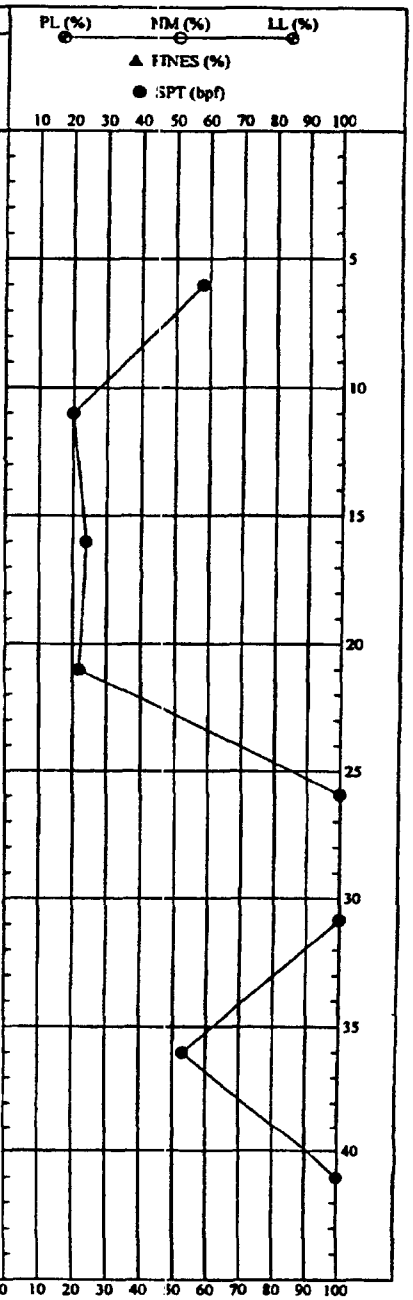
FIGURE 3.2-10

SOIL TEST BORING RECORD B-1

REFERENCE NUMBER
BORINGS.DWG

REVISION DATE: DECEMBER 2003

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"
0	REDDISH BROWN, DRY, SILTY, FINE SAND WITH SOME FINE ROOTS - EOLIAN		3422.2			
	VERY DENSE, LIGHT YELLOW, DRY, FINE SILTY SAND WITH CLASTS OF CEMENTED SAND - CALICHE FROM 6.0' - 7.5'					
5			3417.2	SPT-1		13-29-29
10	FIRM TO VERY FIRM, LIGHT YELLOW, DRY, SILTY FINE TO MEDIUM SAND		3412.2	SPT-3		11-10-10
15			3407.2	SPT-4		9-12-12
20	VERY FIRM TO VERY DENSE, LIGHT YELLOW, SILTY FINE TO MEDIUM SAND WITH CLASTS OF CEMENTED SAND FROM 25.0' TO 35.0'		3402.2	SPT-5		13-10-12
25			3397.2	SPT-6		15-50/5"
30			3392.2	SPT-7		50/1"
35	VERY HARD, DARK RED AND PURPLE, MOIST, HIGH PLASTICITY CLAY		3387.2	SPT-8		14-23-30
40			3382.2	SPT-9		12-33-50/5"
	BORING TERMINATED AT 41.4'					
45			3377.2			



REMARKS. STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/9/2003.

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 9, 2003 **BORING NO.:** B-2

SOIL 1045031049 01.0#1 LAW GIBB.GDT 10/3/03

FIGURE 3.2-11

SOIL TEST BORING RECORD B-2

REFERENCE NUMBER

BORINGS.DWG

REVISION DATE: DECEMBER 2003

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW	LEGEND	ELEV (ft)	SAMPLES IDENT	SAMPLES TYPE	SAMPLES N-COUNT (1st 6" 2nd 6" 3rd 6")
0	REDDISH BROWN, DRY, SILTY FINE SANDY WITH SOME ROOTS - EOLIAN		3412.5			
	VERY DENSE, REDDISH BROWN, DRY, SILTY FINE TO MEDIUM SAND WITH CLASTS OF CEMENTED SAND					
5			3407.5	SPT-1		30-50/5"
10			3402.5	SPT-2		33-50/6"
15	VERY DENSE, LIGHT YELLOW, DRY SILTY FINE TO MEDIUM SAND - CALICHE		3397.5	SPT-3		50/1"
20	VERY DENSE, REDDISH YELLOW, DRY SILTY FINE TO MEDIUM SAND WITH CLASTS OF CEMENTED SAND AND SOME FINE SUBANGULAR TO ROUNDED GRAVEL		3392.5	SPT-4		22-40-50/3"
25	VERY DENSE, LIGHT YELLOW, DRY SILTY FINE TO MEDIUM CEMENTED SAND - CALICHE		3387.5	SPT-5		50/2"
30			3382.5	SPT-6		50/2"
35	VERY DENSE, REDDISH BROWN, DRY, SILTY FINE TO MEDIUM SAND		3377.5	SPT-7		50/3"
40	VERY HARD, DARK RED, DRY, HIGH PLASTICITY CLAY		3372.5	SPT-8		23-50/6"
45			3367.5			

PL (%) NM (%) LL (%)
▲ FINES (%)
● SPT (bpf)
10 20 30 40 50 60 70 80 90 100

SOIL 3045031049 01 GPJ LAW GIRB.GDT 10/3/03

REMARKS STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION BACK FILLED ON 9/10/2003

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 10, 2003 **BORING NO.:** B-3

SHEET 1 OF 3

REFERENCE NUMBER BORINGS.DWG

FIGURE 3.2-12
SOIL TEST BORING RECORD B-3

REVISION DATE: DECEMBER 2003

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"	PL (%) NM (%) LL (%) ▲ FINES (%) ● SPT (bpf)
45	VERY HARD, DARK RED, DRY, HIGH PLASTICITY CLAY		3367.5	SPT-9		27-50/5"	
50			3362.5	SPT-10		39-50/2"	
55	VERY HARD, DARK RED AND PURPLE, DRY, HIGH PLASTICITY CLAY		3357.5	SPT-11		35-50/4"	
60			3352.5	SPT-12		31-50/5"	
65			3347.5	SPT-13		32-50/4"	
70			3342.5	SPT-14		22-50/5"	
75			3337.5	SPT-15		39-50/4"	
80	VERY HARD, DARK RED AND PURPLE, DRY, HIGH PLASTICITY CLAY WITH OCCASIONAL THIN CEMENTED LAYERS OF GREENISH GRAY		3332.5	SPT-16		50/4"	
85	VERY HARD, REDDISH PURPLE WITH GRAY MOTTLING, DRY HIGH PLASTICITY CLAY		3327.5	SPT-17		50/6"	
90			3322.5				

SOIL 3045031049 01.GPJ LAW GIBB.GDT 10/3/03

REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/10/2003

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 10, 2003 **BORING NO.:** B-3

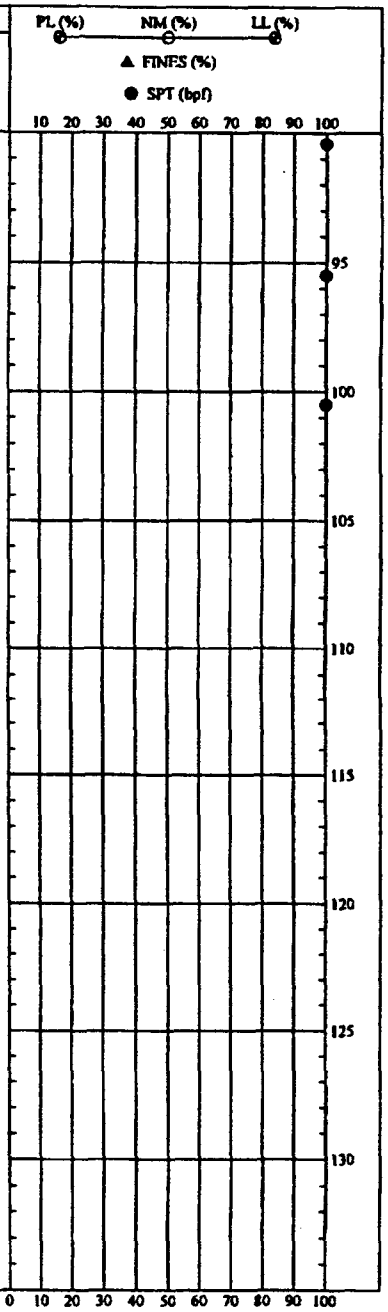
SHEET 2 OF 3

REFERENCE NUMBER
BORINGS.DWG

FIGURE 3.2-12
SOIL TEST BORING RECORD B-3

REVISION DATE: DECEMBER 2003

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS	LEGEND	ELEV (ft)	SAMPLES IDENT	TYPE	N-COUNT 1st 6" 2nd 6" 3rd 6"	PL (%) NM (%) LL (%) ▲ FINES (%) ● SPT (bpf)
90	SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.						
	VERY HARD, RED AND PURPLE, DRY, HIGH PLASTICITY CLAY		3322.5	SPT-18		50/5"	
95			3317.5	SPT-19		50/6"	
100			3312.5	SPT-20		50/6"	
	BORING TERMINATED AT 100.5'						
105			3307.5				
110			3302.5				
115			3297.5				
120			3292.5				
125			3287.5				
130			3282.5				
135			3277.5				



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/10/2003.

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 10, 2003 **BORING NO.:** B-3

SOIL 304503\049 01.OPJ LAW GIBB.GDT 10/3/03

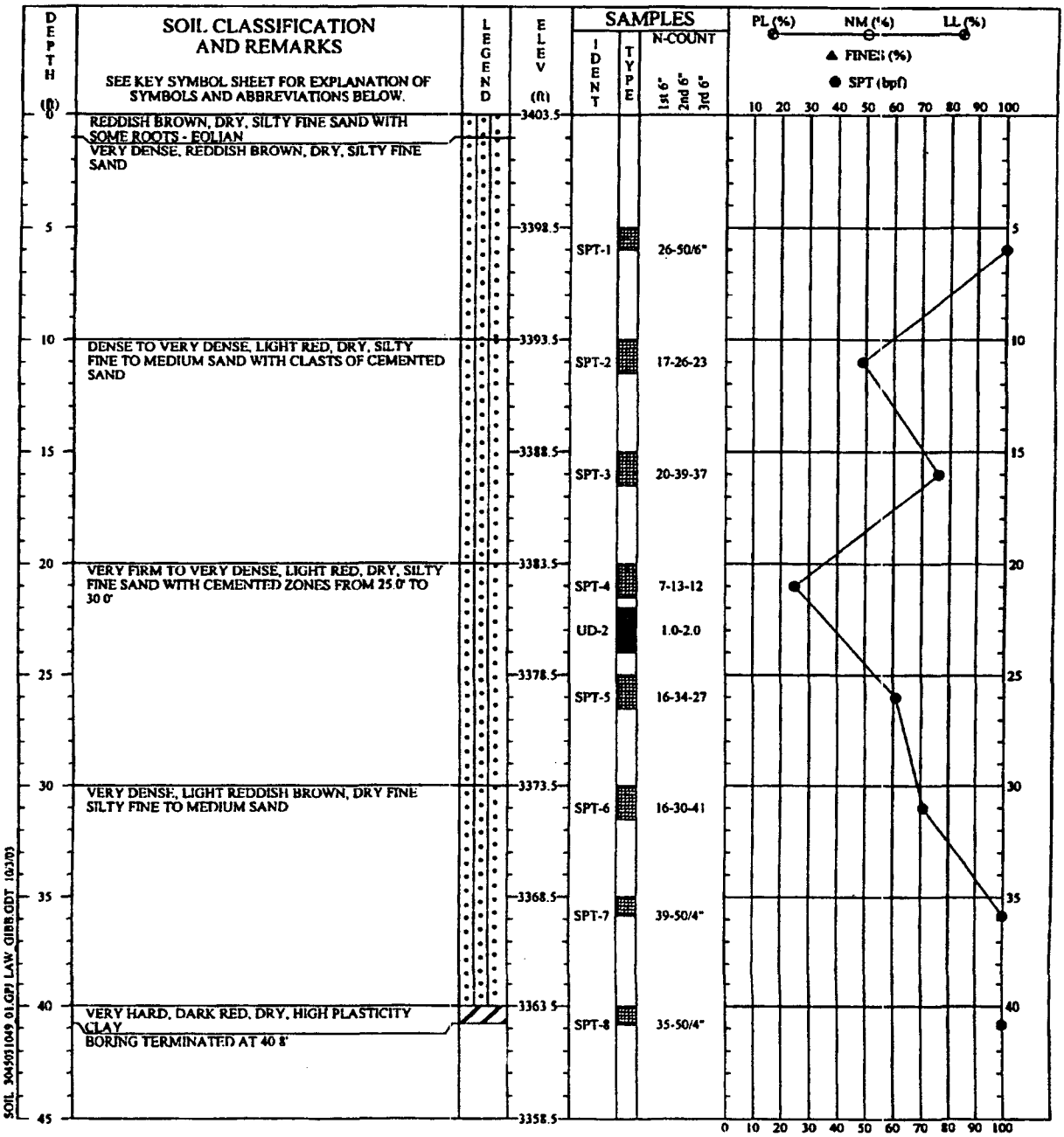
SHEET 3 OF 3

REFERENCE NUMBER BORINGS.DWG

FIGURE 3.2-12

SOIL TEST BORING RECORD B-3

REVISION DATE: DECEMBER 2003



REMARKS: STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/9/2003.

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

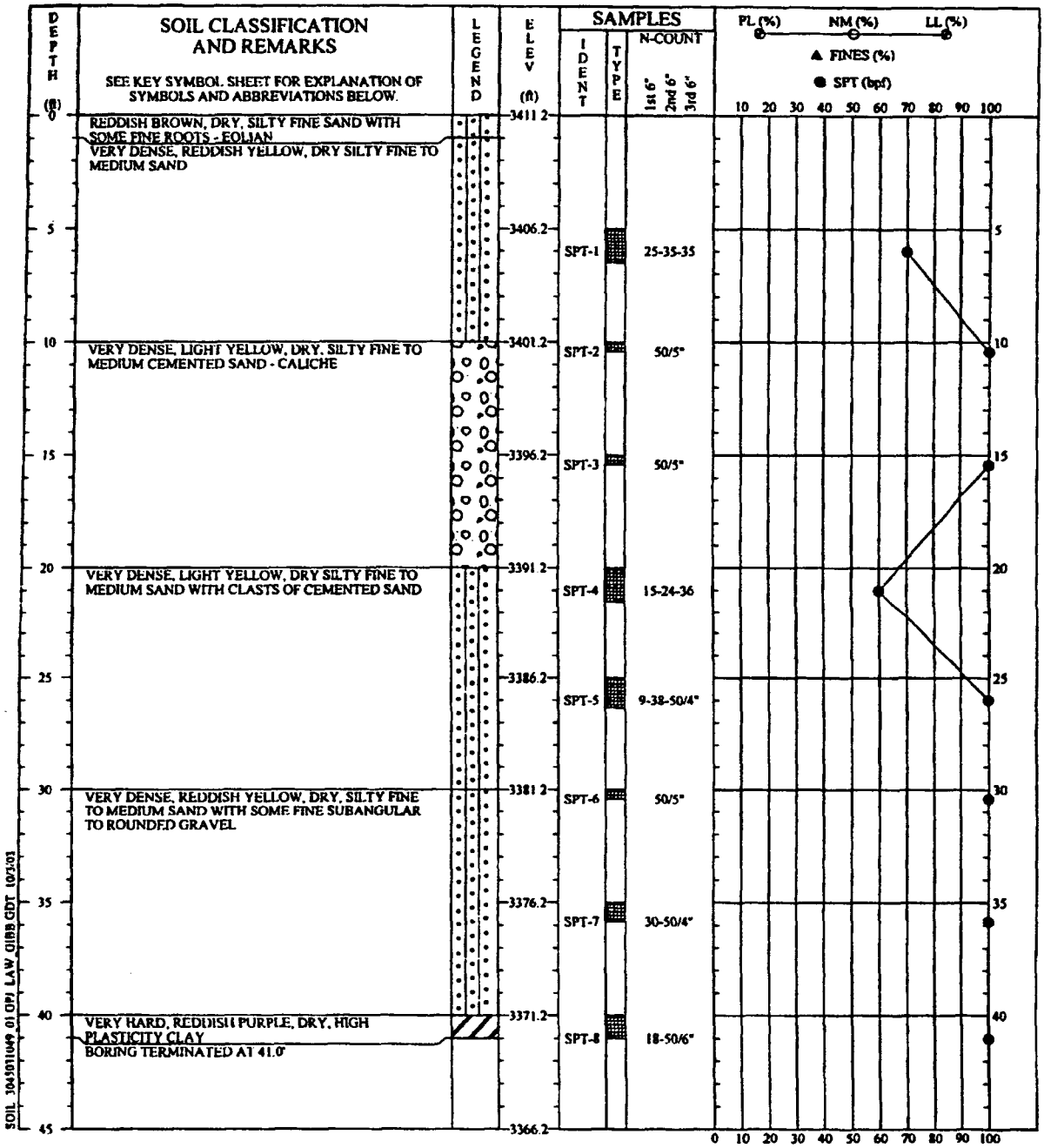
DRILLED: September 9, 2003 **BORING NO.:** B-4

FIGURE 3.2-13

SOIL TEST BORING RECORD B-4

REFERENCE NUMBER BORINGS.DWG

REVISION DATE: DECEMBER 2003



REMARKS. STANDARD PENETRATION RESISTANCE TESTING PERFORMED USING A SAFETY HAMMER. NO GROUND WATER ENCOUNTERED AT TIME OF EXPLORATION. BACK FILLED ON 9/10/2003.

SOIL TEST BORING RECORD

PROJECT: NEF - Lea County, New Mexico

DRILLED: September 10, 2003 **BORING NO.:** B-5

FIGURE 3.2-14

SOIL TEST BORING RECORD B-5

REFERENCE NUMBER

BORINGS.DWG

REVISION DATE: DECEMBER 2003

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

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 200 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)

	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

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

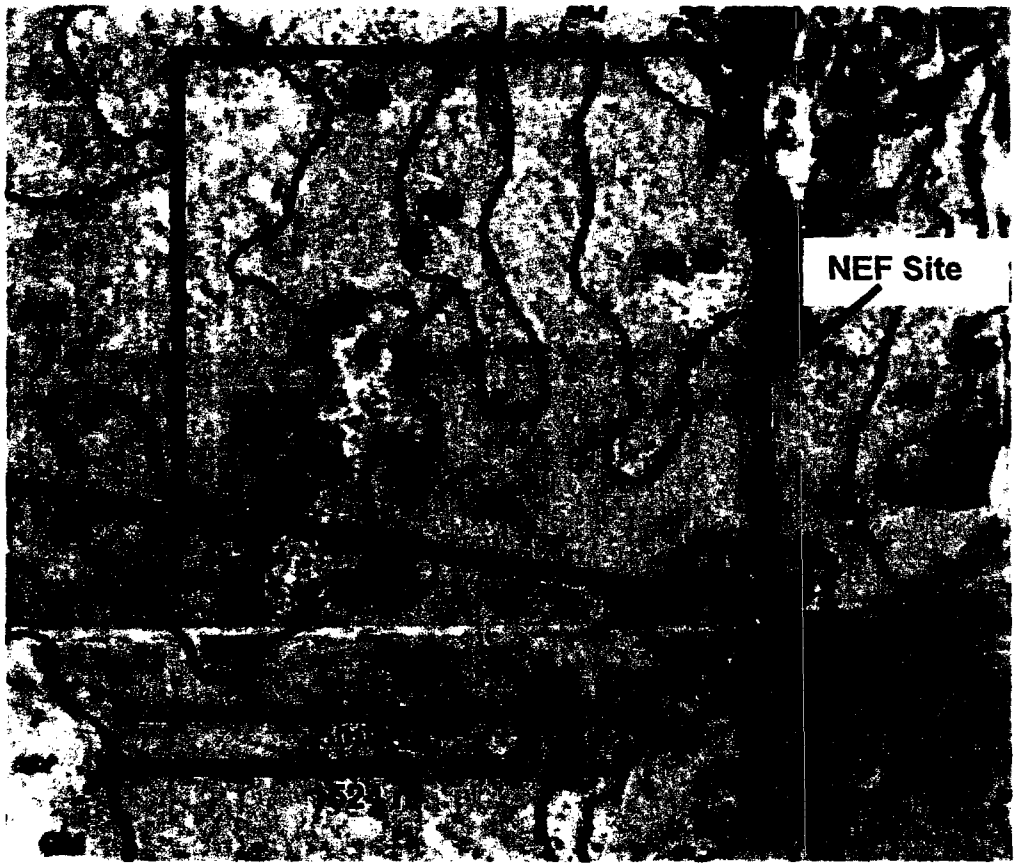
boringlkey.dwg
BORINGFIGURES.dwg

LES

FIGURE 3.2-15

SOIL TEST BORING KEY TO SYMBOLS AND DESCRIPTIONS

REVISION DATE: DECEMBER 2003



USDA SOIL DESIGNATION	SOIL NAME/DESCRIPTION	UNIFIED SOIL CLASSIFICATION DESIGNATION(S)
Aa	ACTIVE (SAND) DUNE LAND.	SP
BO	BROWNFIELD-SPRINGER ASSOCIATION: MOSTLY FINE SAND WITH LOAM FINE SAND; LEVEL TO UNDULATING TOPOGRAPHY; MODERATELY RAPID PERMEABLILITY AND SLOW RUNOFF.	SM
BS	BROWNFIELD-SPRINGER ASSOCIATION: MOSTLY FINE SAND WITH LOAM FINE SAND; DUNES AND HUMMOCKS FOR CONCAVE AND CONVEX ROLLING TERRAIN; DRAINAGE SIMILAR TO BO.	SM
KM	KERMIT SOILS AND DUNE LAND: EXCESSIVELY-DRAINED NON-CALCAREOUS SOILS; HUMMOCKY AND UNDULATING TOPOGRAPHY DUE TO EOLIAN PROCESSES.	SP-SM OR SM
MU	MIXED ALLUVIAL LANDS: UNCONSOLIDATED, STRATIFIED ALLUVIUM WITH VARIED TEXTURES OCCURRING INTERMITTENTLY IN DRAINAGE-WAYS A FEW FEET IN THICKNESS; MODERATE TO RAPID PERMEABILITY WITH SLOW RUNOFF.	VARIABLE
PG	PORTALES AND GOMEZ FINE SANDY LOAMS: LIGHT CLAY LOAM, WELL-DRAINED.	VARIABLE

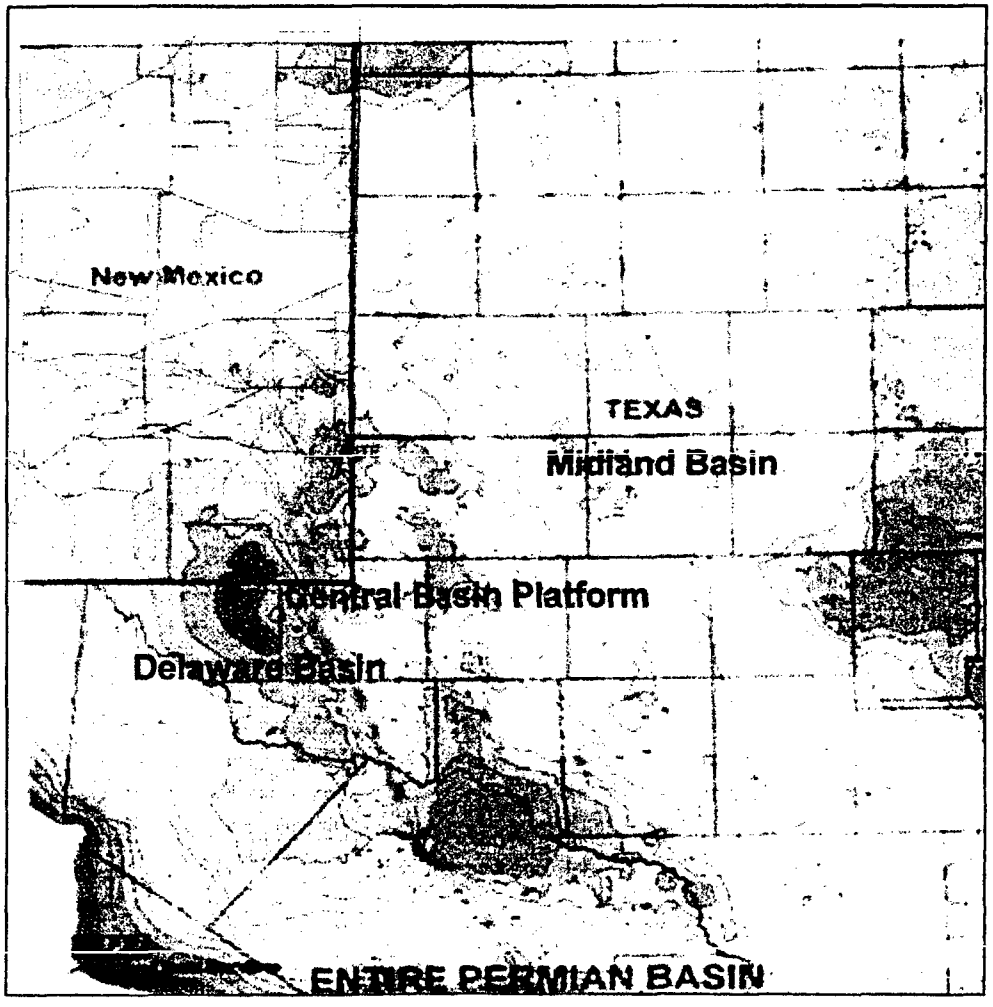
SOURCE: (USDA, 1974)

NORTH

REFERENCE NUMBER
Figure 3.2–16.dwg

FIGURE 3.2-16
SITE SOILS MAP
(USDA, 1974)

REVISION DATE: DECEMBER 2003



LEGEND

☆ NEF SITE

REFERENCE:

TALLEY, D.J., 1997, CHARACTERIZATION OF A SAN ANDRES CARBONATE RESERVOIR USING FOUR DIMENSIONAL, MULTICOMPONENT ATTRIBUTE ANALYSIS, MASTER OF SCIENCE THESIS, COLORADO SCHOOL OF MINES.

NORTH

60 0 60 120 180 KM

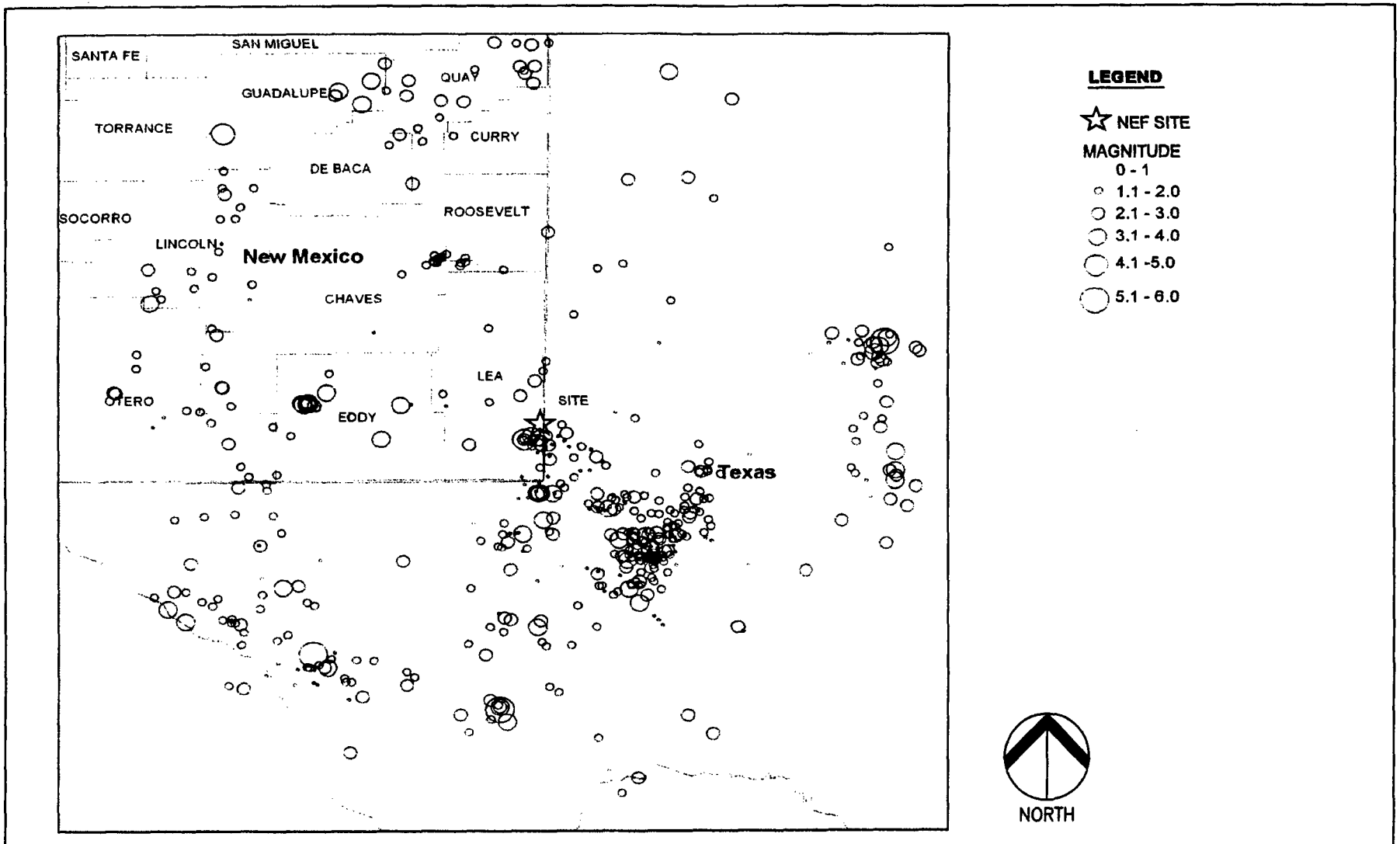
30 0 30 60 90 120 MILES

REFERENCE NUMBER
1Figures 3.2.dwg

FIGURE 3.2-17

TECTONIC SUBDIVISIONS OF THE PERMIAN BASIN

REVISION DATE: DECEMBER 2003



0 100 200 300 400 KM

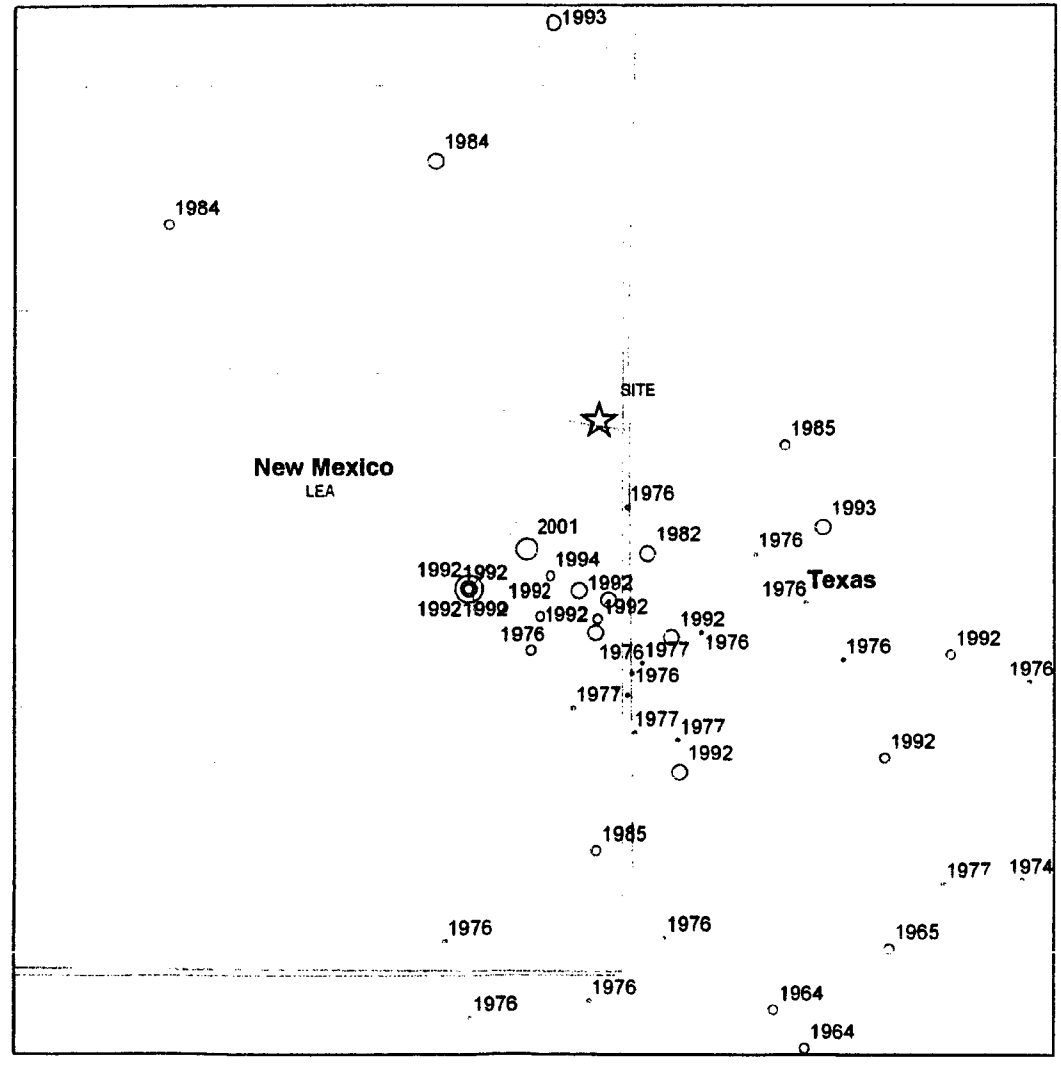
0 50 100 150 200 MILES

REFERENCE NUMBER
1Fig 3.2.dwg

FIGURE 3.2-18

SEISMICITY MAP FOR 322 KILOMETERS (200 MILE) RADIUS OF THE NEF SITE

REVISION DATE: DECEMBER 2003



LEGEND

NEF SITE

MAGNITUDE

- 0 - 1
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 -5.0
- 5.1 - 6.0

NORTH

10 0 10 20 30 40 KM

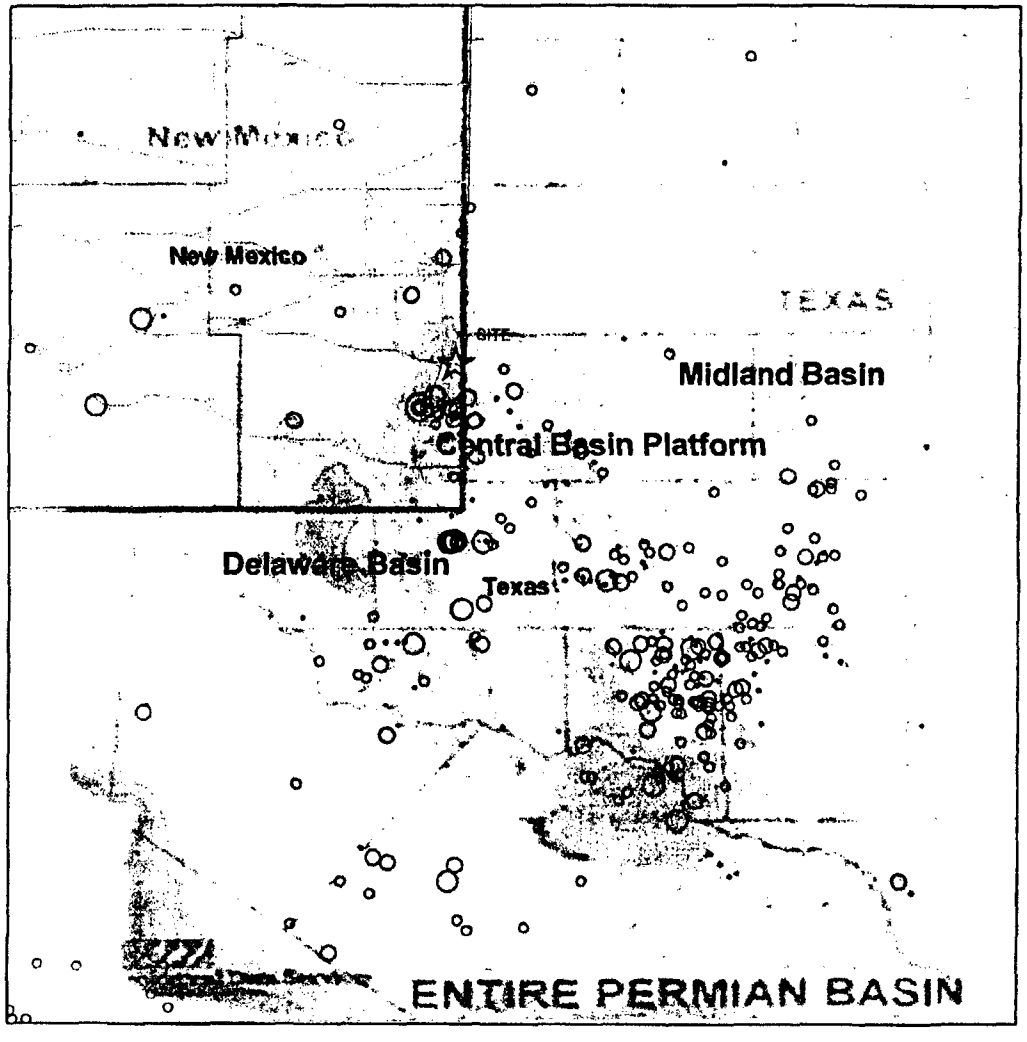
5 0 5 10 15 20 MILES

REFERENCE NUMBER
Figures 3.2.dwg

FIGURE 3.2-19

SEISMICITY IN THE IMMEDIATE VICINITY OF THE NEF SITE

REVISION DATE: DECEMBER 2003



LEGEND

☆ NEF SITE

MAGNITUDE

- 0 - 1
- 1.1 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 -5.0
- 5.1 - 6.0

NORTH

40 0 40 80 120 160 KM

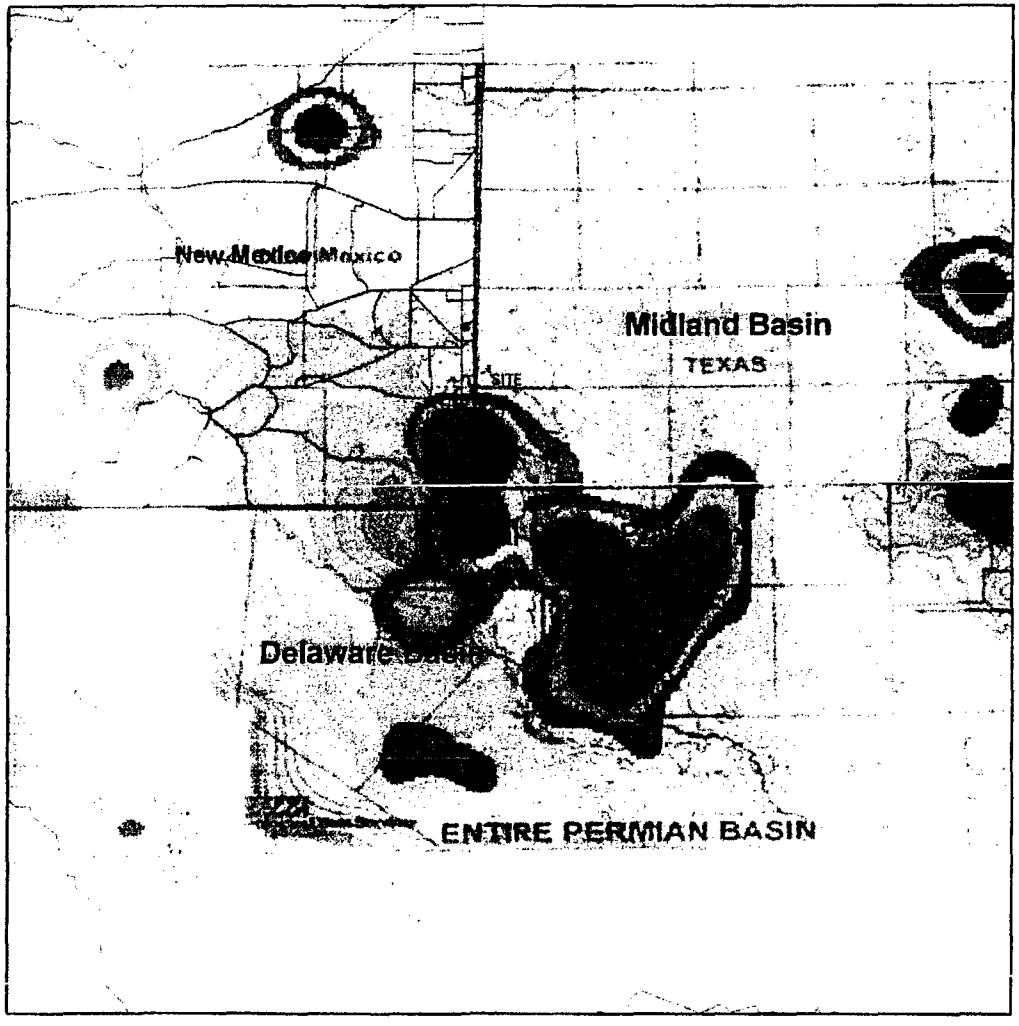
20 0 20 40 60 80 MILES

REFERENCE NUMBER
Figu 2.dwg

FIGURE 3.2-20

REGIONAL SEISMICITY AND TECTONIC ELEMENTS OF THE PERMIAN BASIN

REVISION DATE: DECEMBER 2003



LEGEND

☆ NEF SITE

epicenters
EARTHQUAKE DENSITY
0 - 40
40 - 86
86 - 133
133 - 705

NOTE:
THE EARTHQUAKE FREQUENCY CONTOURS SHOWN PROVIDE A VISUAL PORTRAYAL OF THE AREAS WITH SIMILAR EARTHQUAKE COUNTS PER AREA, i.e., EARTHQUAKE DENSITY. THE DENSITY UNITS THEMSELVES ARE NOT ABSOLUTE, BUT A RELATIVE REPRESENTATION OF EARTHQUAKE FREQUENCY FROM ONE LOCATION TO ANOTHER LOCATION.

2

NORTH

60 0 60 120 180 240 KM

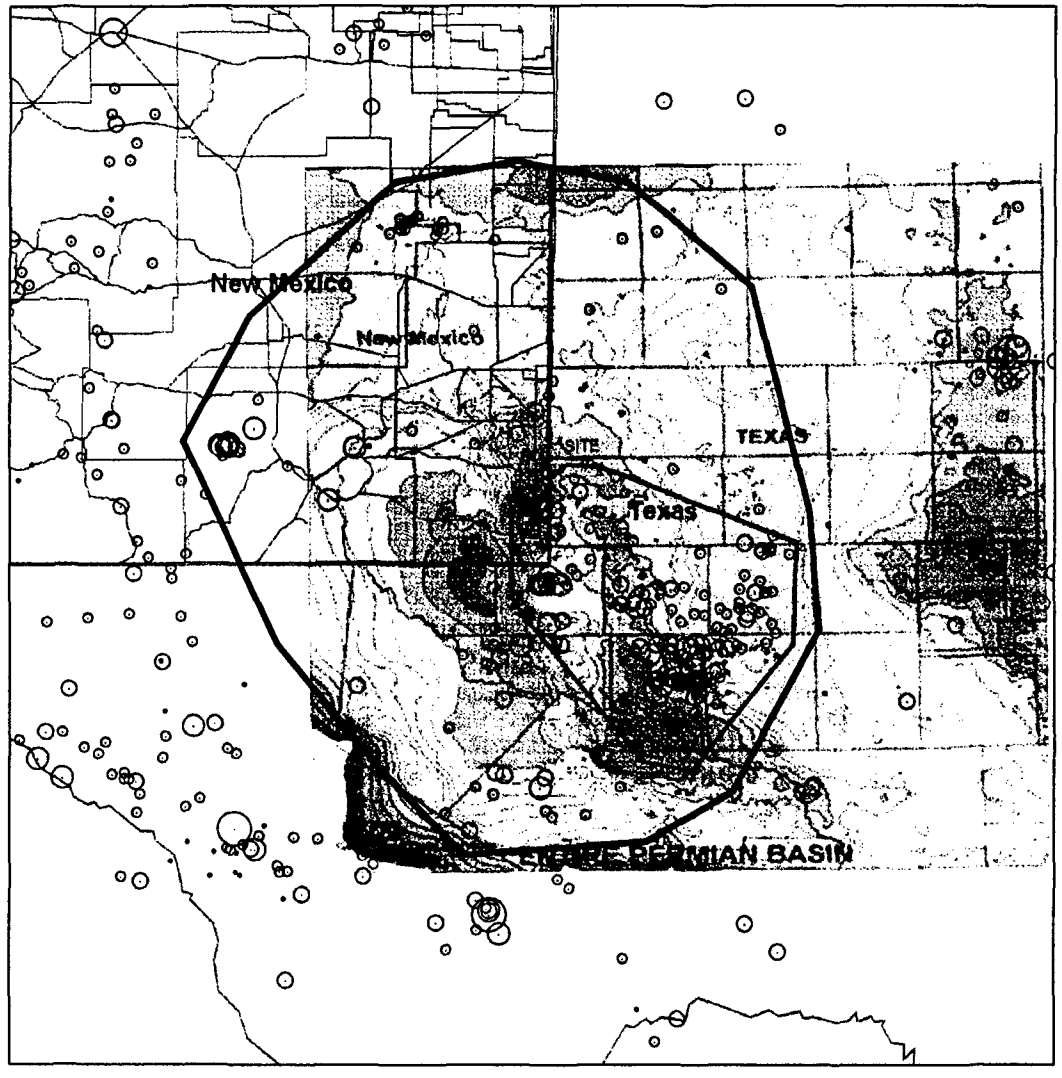
30 0 30 60 90 120 150 MILES

REFERENCE NUMBER
Figures 3.2.dwg

FIGURE 3.2-21

EARTHQUAKE FREQUENCY CONTOURS AND TECTONIC ELEMENTS OF THE PERMIAN BASIN

REVISION 2 DATE: JULY 2004



LEGEND

- NEF SITE
- MAGNITUDE
  - 0 - 1
  - 1.1 - 2.0
  - 2.1 - 3.0
  - 3.1 - 4.0
  - 4.1 -5.0
  - 5.1 - 6.0
  - epicenters
- CENTRAL BASIN PLATFORM EARTHQUAKE CLUSTER
- REGION 1

NORTH

0 100 200 300 KM

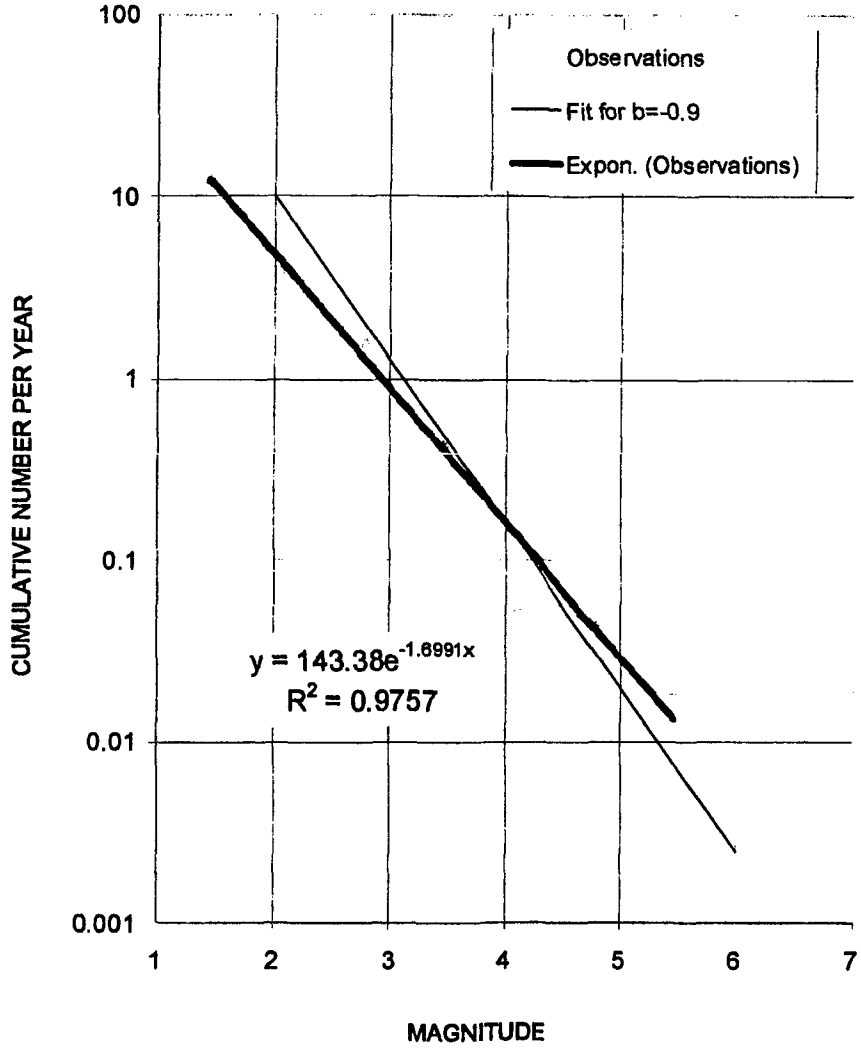
0 50 100 150 200 MILES

REFERENCE NUMBER
2Fig[illegible]3.2.dwg

FIGURE 3.2-22

SEISMIC SOURCE AREAS FOR EARTHQUAKE FREQUENCY STATISTICAL ANALYSES

REVISION 1 DATE: FEBRUARY 2004



Exponential Best Fit

Log(Nc) = 2.15 – 0.74(M)

Fit assuming b = -0.90

Log(Nc) = 2.80 – 0.90(M)

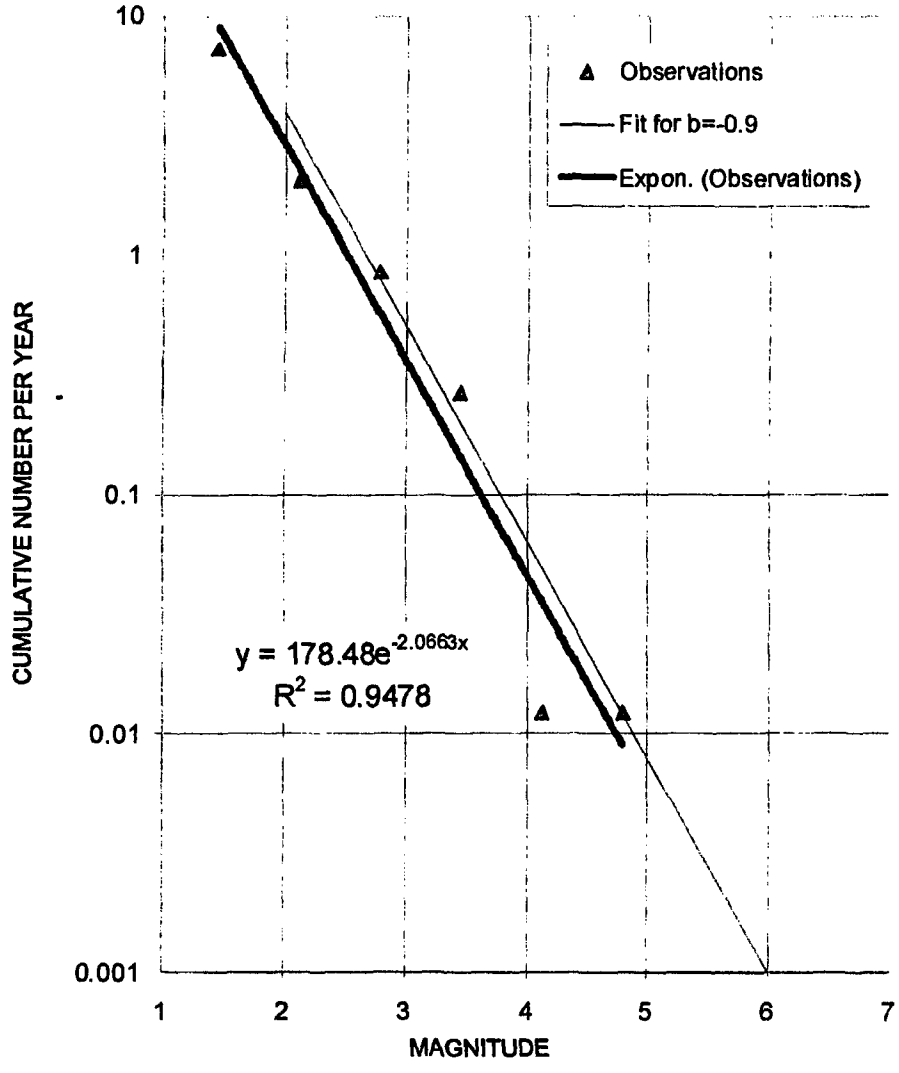
M IS MAGNITUDE SCALED TO DURATION MAGNITUDE AS DESCRIBED IN NEW MEXICO TECH CATALOGS CIRULAR 210, 2002

REFERENCE NUMBER
2Figures3.2.dwg

FIGURE 3.2-23

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

REVISION DATE: DECEMBER 2003



Exponential Best Fit

Log(Nc) = 2.25 – 0.89(M)

Fit assuming b = -0.90

Log(Nc) = 2.40 – 0.90(M)

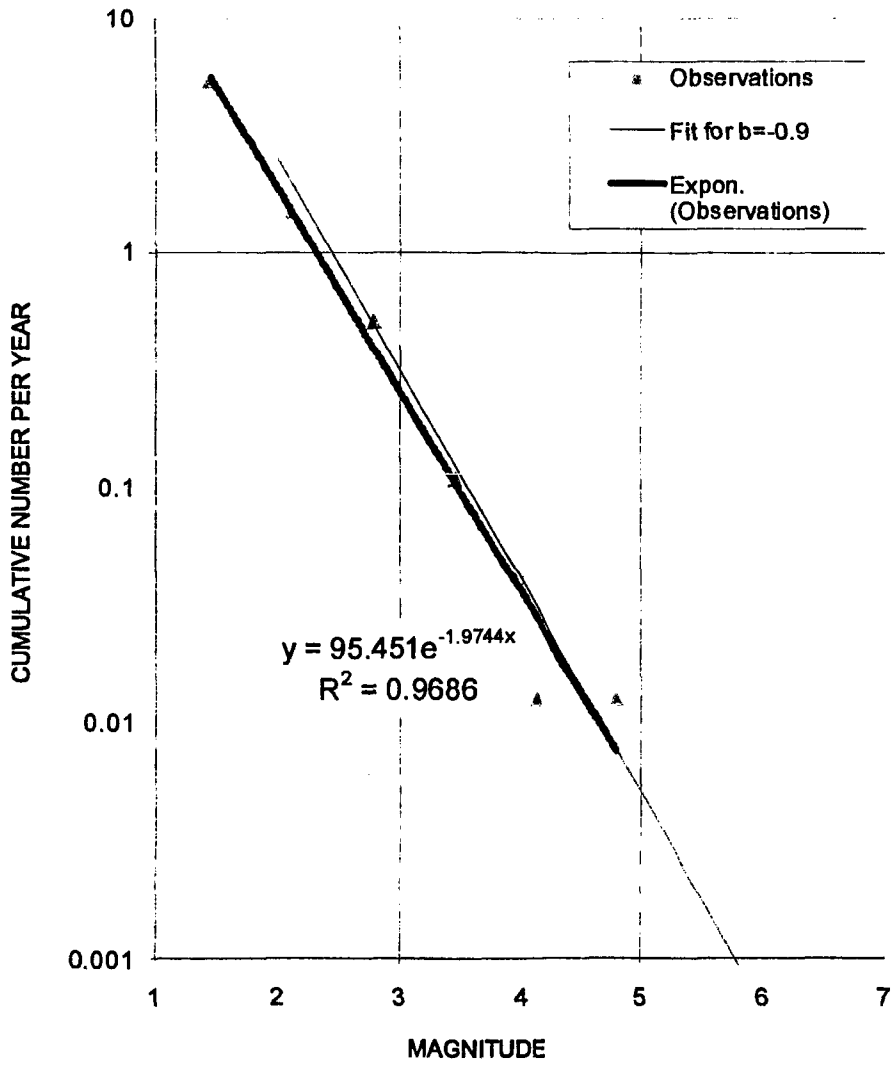
M IS MAGNITUDE SCALED TO DURATION MAGNITUDE AS DESCRIBED IN NEW MEXICO TECH CATALOGS CIRULAR 210, 2002

REFERENCE NUMBER
2Fig[illegible]2.dwg

FIGURE 3.2-24

EARTHQUAKE RECURRENCE MODELS FOR REGION 1 (161 KM (100 MILE) RADIUS OF NEF SITE)

REVISION DATE: DECEMBER 2003



Exponential Best Fit

Log(Nc) = 1.98 – 0.86(M)

Fit assuming b = -0.90

Log(Nc) = 2.20 – 0.90(M)

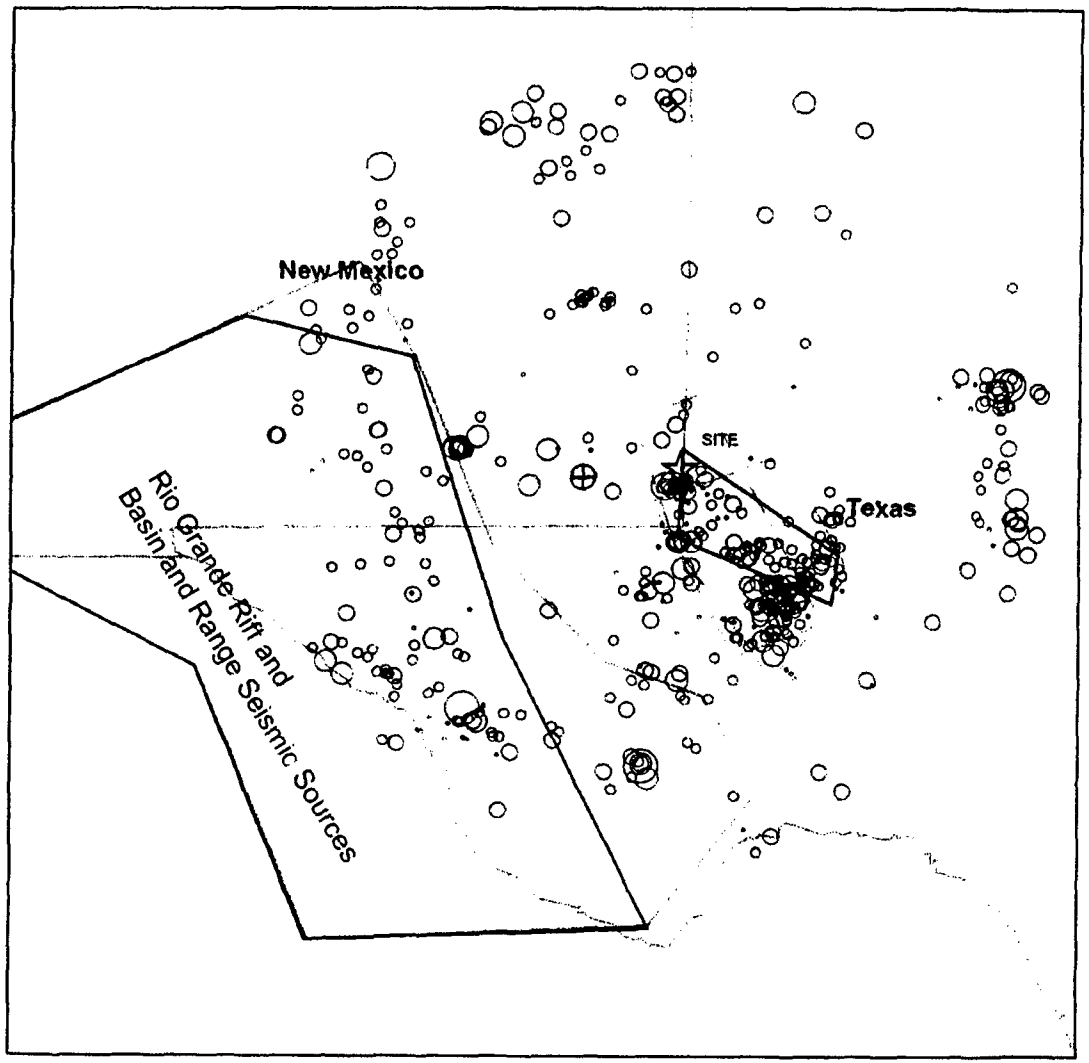
M IS MAGNITUDE SCALED TO DURATION MAGNITUDE AS DESCRIBED IN NEW MEXICO TECH CATALOGS CIRULAR 210, 2002

REFERENCE NUMBER
2Figures3.2.dwg

FIGURE 3.2-25

EARTHQUAKE RECURRENCE MODELS FOR REGION 2 (CBP HIGHER DENSITY EARTHQUAKE CLUSTER)

REVISION DATE: DECEMBER 2003



LEGEND

- NEF SITE
- MAGNITUDE
  - 0 - 1
  - 1.1 - 2.0
  - 2.1 - 3.0
  - 3.1 - 4.0
  - 4.1 -5.0
  - 5.1 - 6.0
- BASIN AND RANGE Sub A
- BASIN AND RANGE Sub B
- CENTRAL BASIN PLATFORM A
- CENTRAL BASIN PLATFORM B
- CENTRAL BASIN PLATFORM C
- WIPP SITE

REFERENCE:

DOE/WIPP-95-2065 REV. 7
SAFETY ANALYSIS REPORT FOR THE WASTE ISOLATION PILOT PLANT, FIG. 2.5-26

NORTH

100 0 100 200 300 400 KM

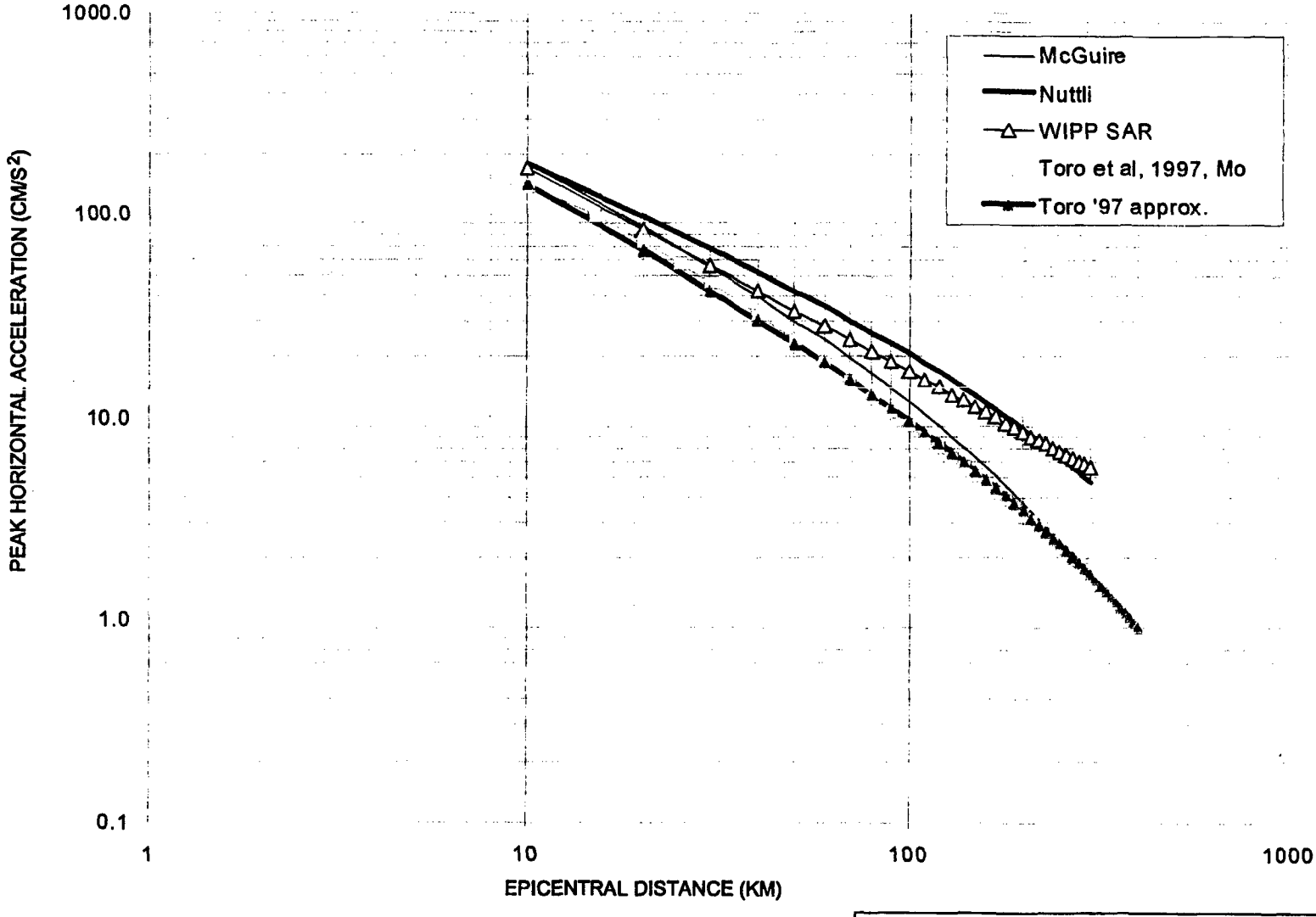
50 0 50 100 150 200 MILES

REFERENCE NUMBER
2Fig[illegible].2.dwg

FIGURE 3.2-26

ALTERNATE SEISMIC SOURCE GEOMETRIES USED IN THE WIPP SEISMIC HAZARD STUDY

REVISION DATE: DECEMBER 2003



REFERENCE NUMBER
2Figures3.2.dwg

FIGURE 3.2-27

COMPARISION OF PGA ATTENUATION
FOR A MAGNITUDE 5.0 EARTHQUAKE

REVISION DATE: DECEMBER 2003

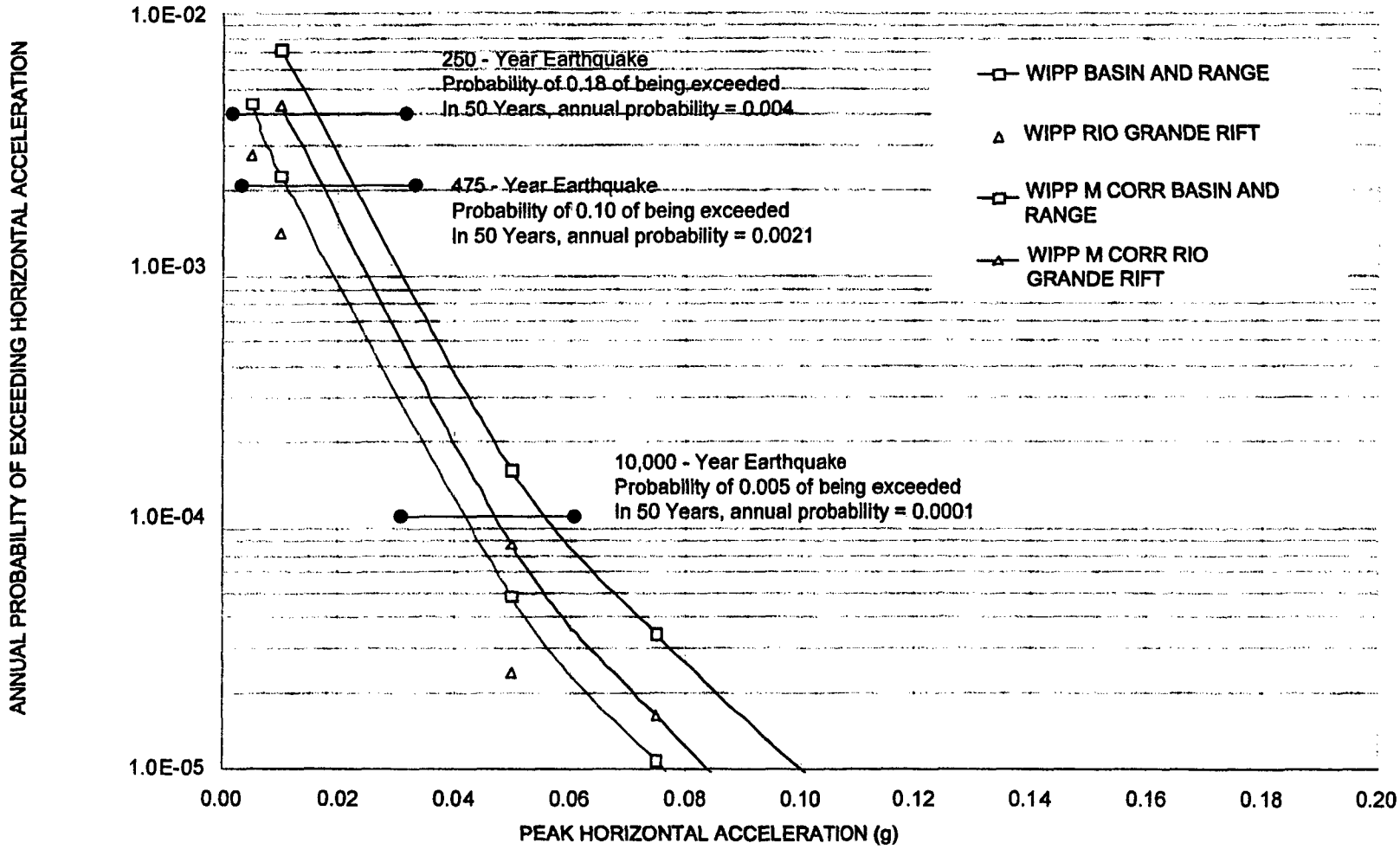
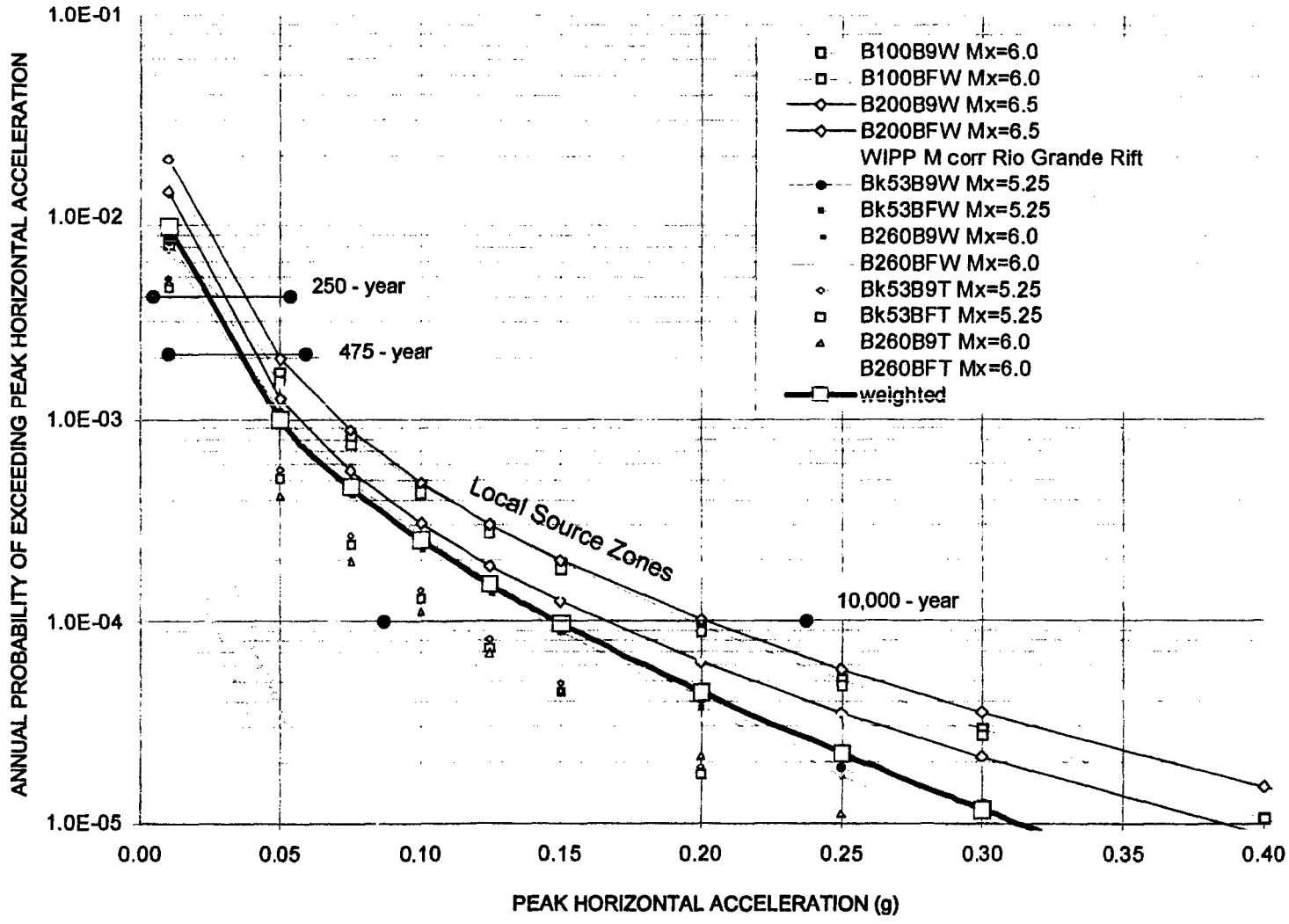


FIGURE 3.2-28

SEISMIC HAZARD AT THE NEF SITE FROM RIO GRANDE RIFT SEISMIC SOURCES

REFERENCE NUMBER
2Fig[illegible].2.dwg

REVISION DATE: DECEMBER 2003

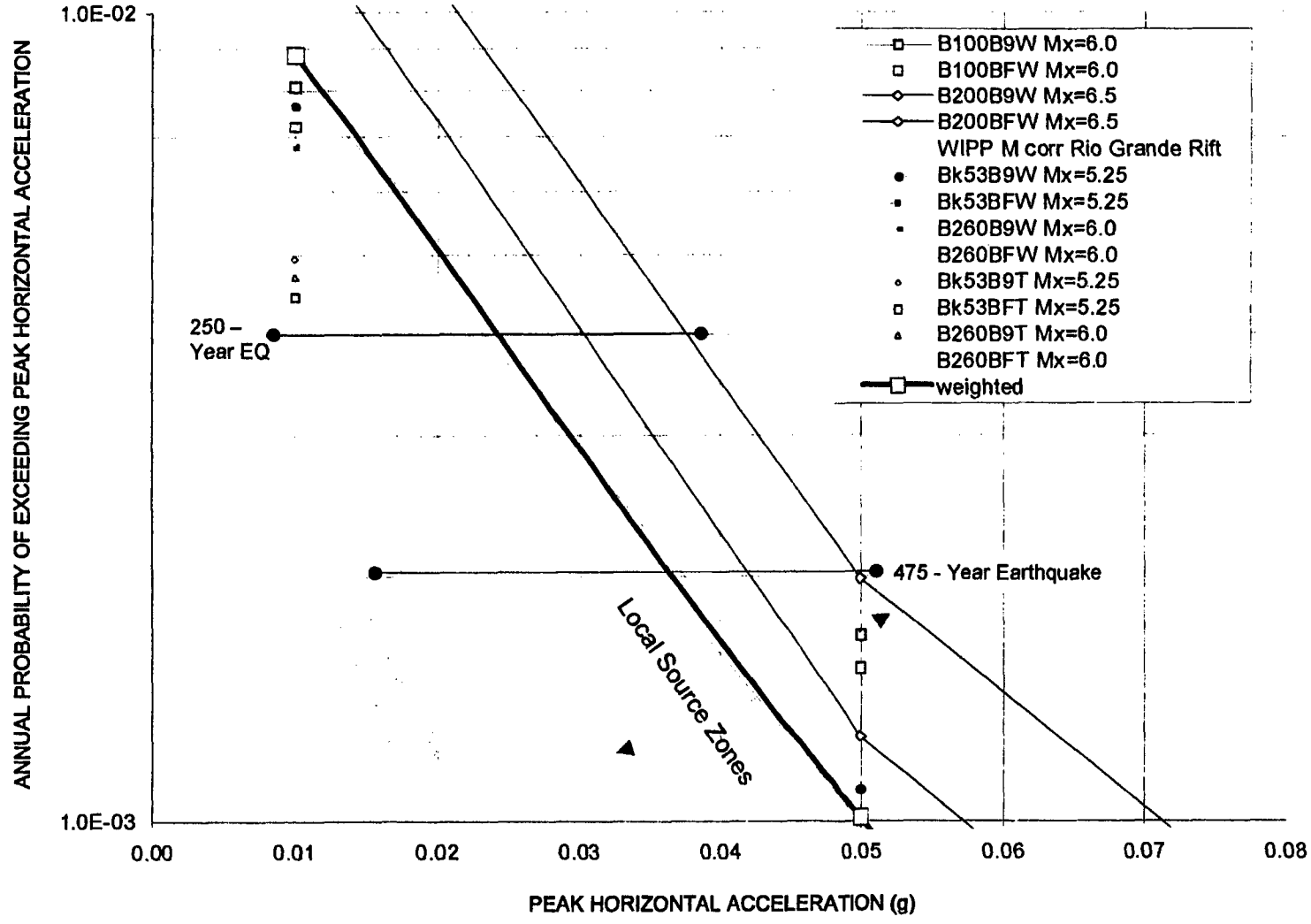


REFERENCE NUMBER
2Figures3.2.dwg

FIGURE 3.2-29

SEISMIC HAZARD AT THE NEF SITE FROM LOCAL SEISMIC SOURCE ZONES

REVISION DATE: DECEMBER 2003



0 100 200 300 KM

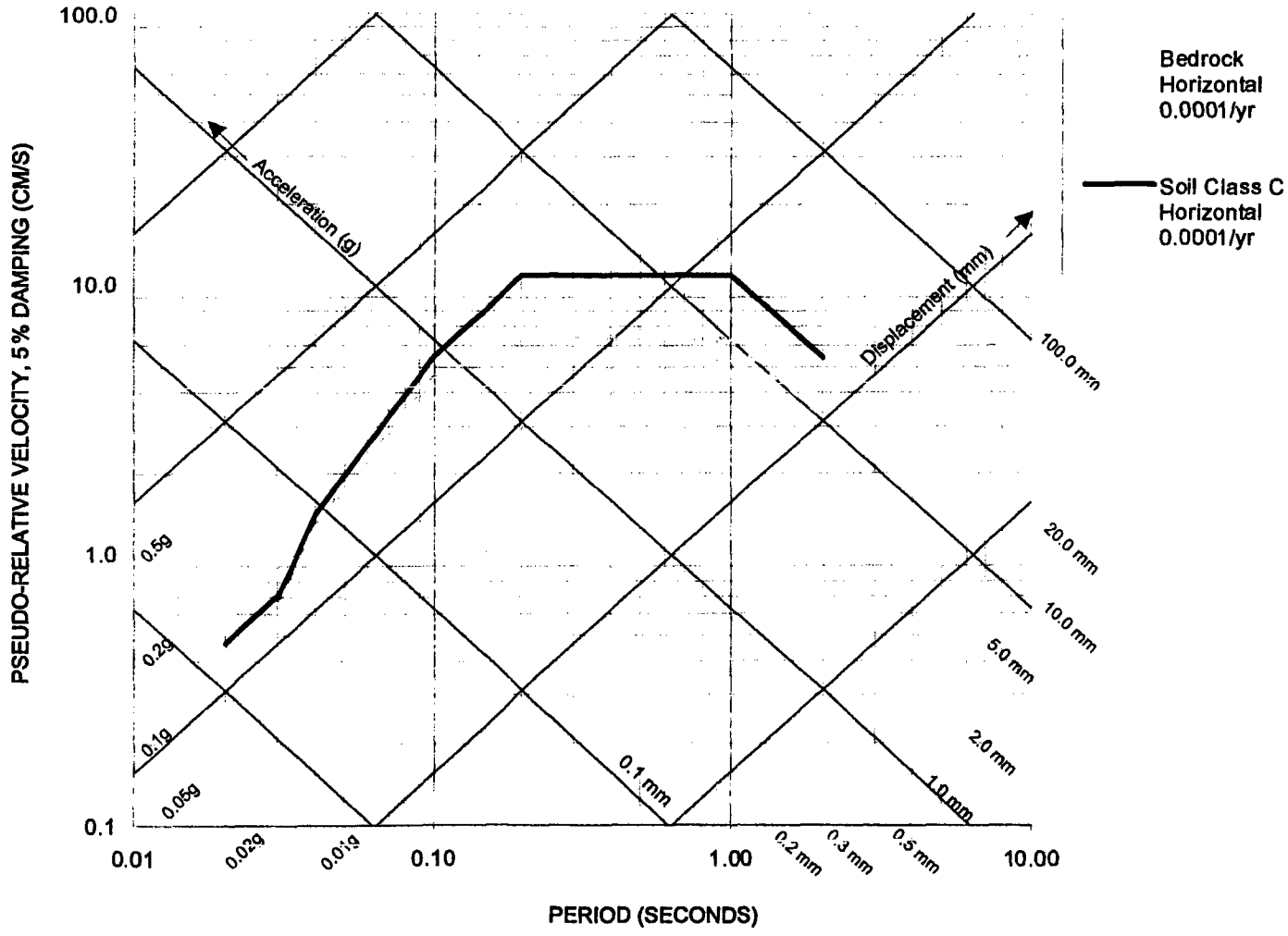
0 50 100 150 200 MILES

REFERENCE NUMBER
2Fi 3.2.dwg

FIGURE 3.2-30

ZOOM OF SEISMIC HAZARD AT THE NEF SITE FROM LOCAL SEISMIC SOURCE ZONES

REVISION DATE: DECEMBER 2003



REFERENCE NUMBER
2Figures3.2.dwg

FIGURE 3.2-31
HORIZONTAL RESPONSE SPECTRA FOR THE 10,000–YEAR EARTHQUAKE – BEDROCK AND SOIL CLASS C FOR THE NEF SITE

REVISION DATE: DECEMBER 2003

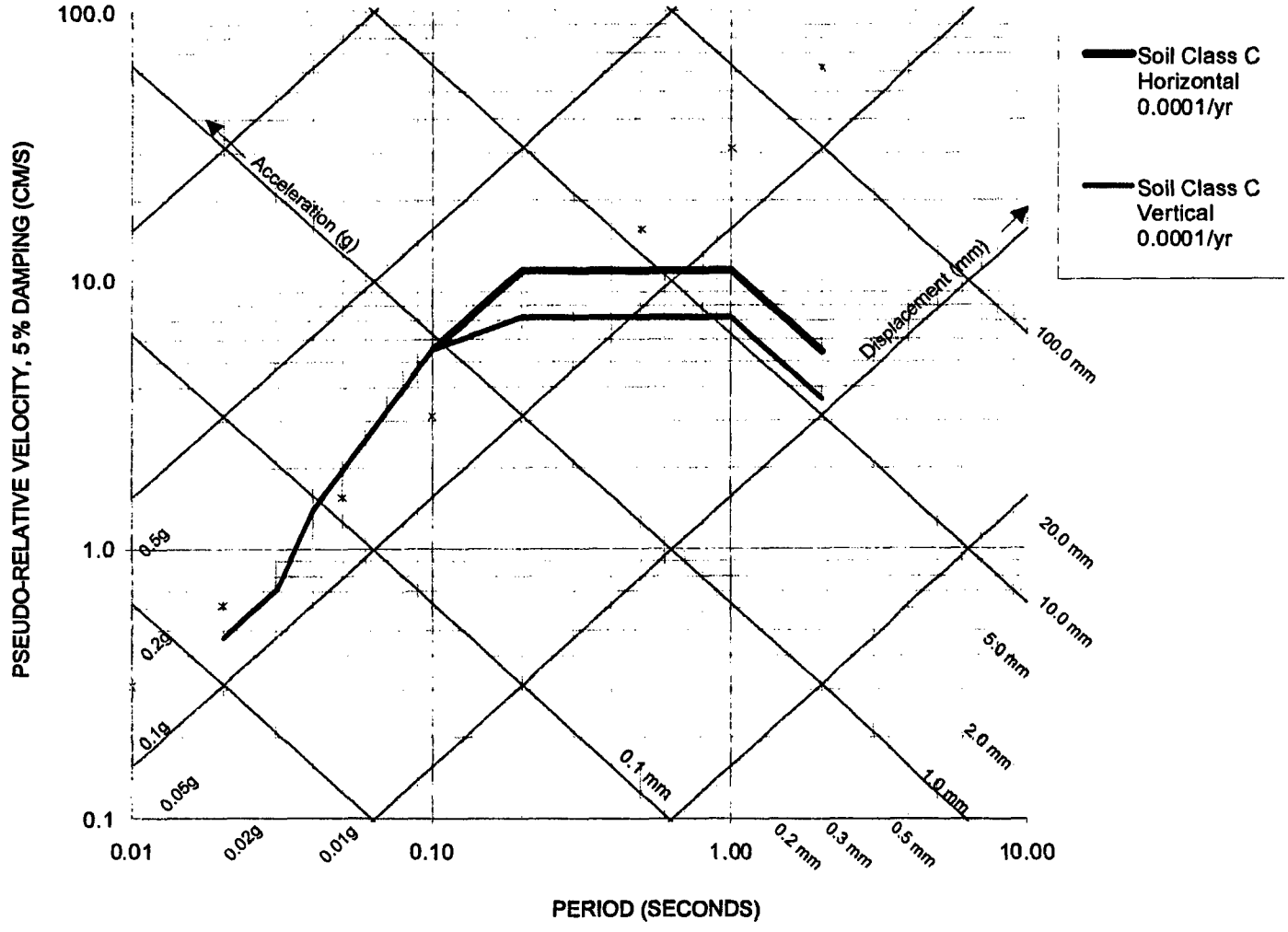
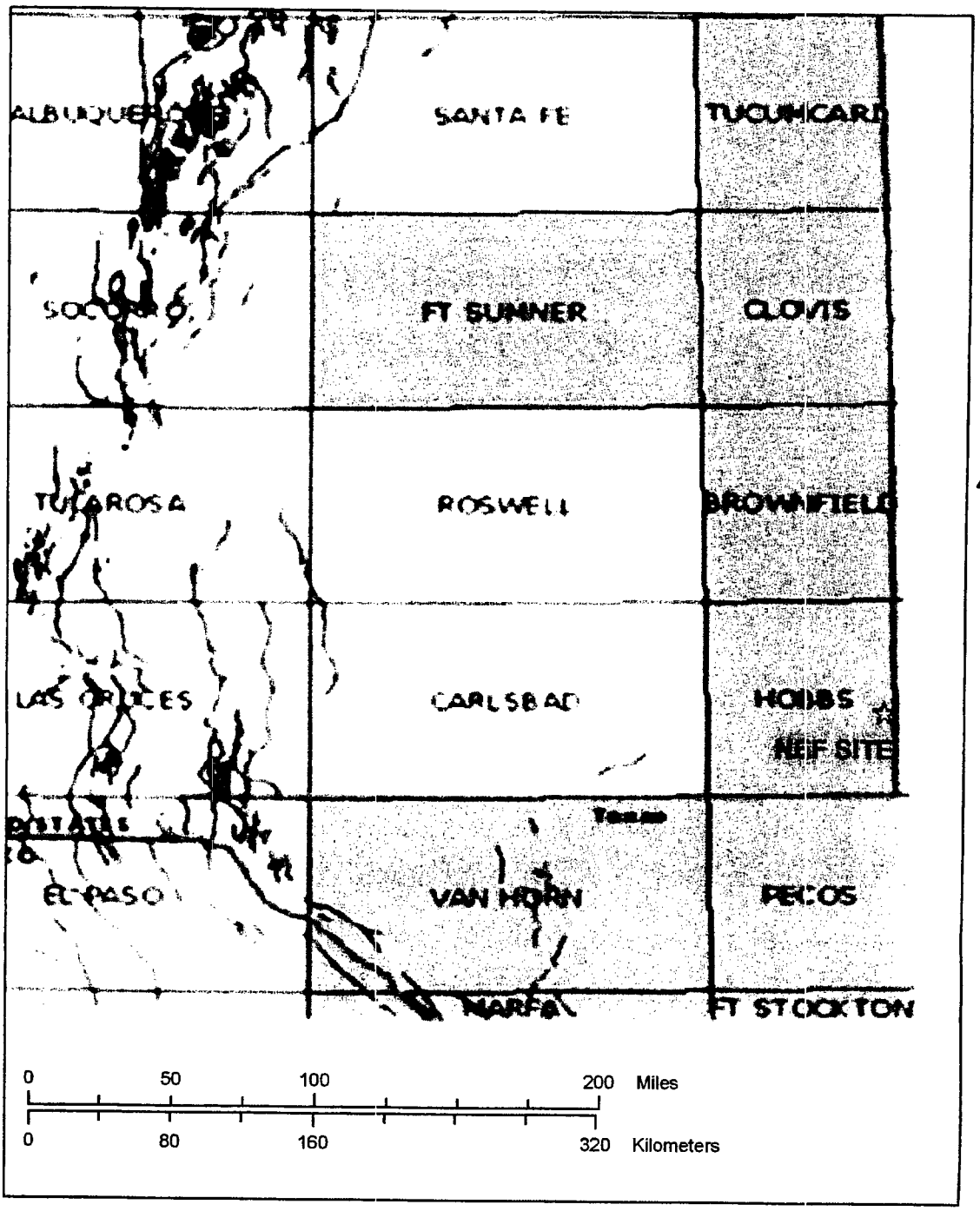


FIGURE 3.2-32
HORIZONTAL AND VERTICAL RESPONSE SPECTRA
FOR THE 10,000-YEAR EARTHQUAKE
SOIL CLASS C FOR THE NEF SITE

REFERENCE NUMBER
2Fig[illegible].2.dwg

REVISION DATE: DECEMBER 2003

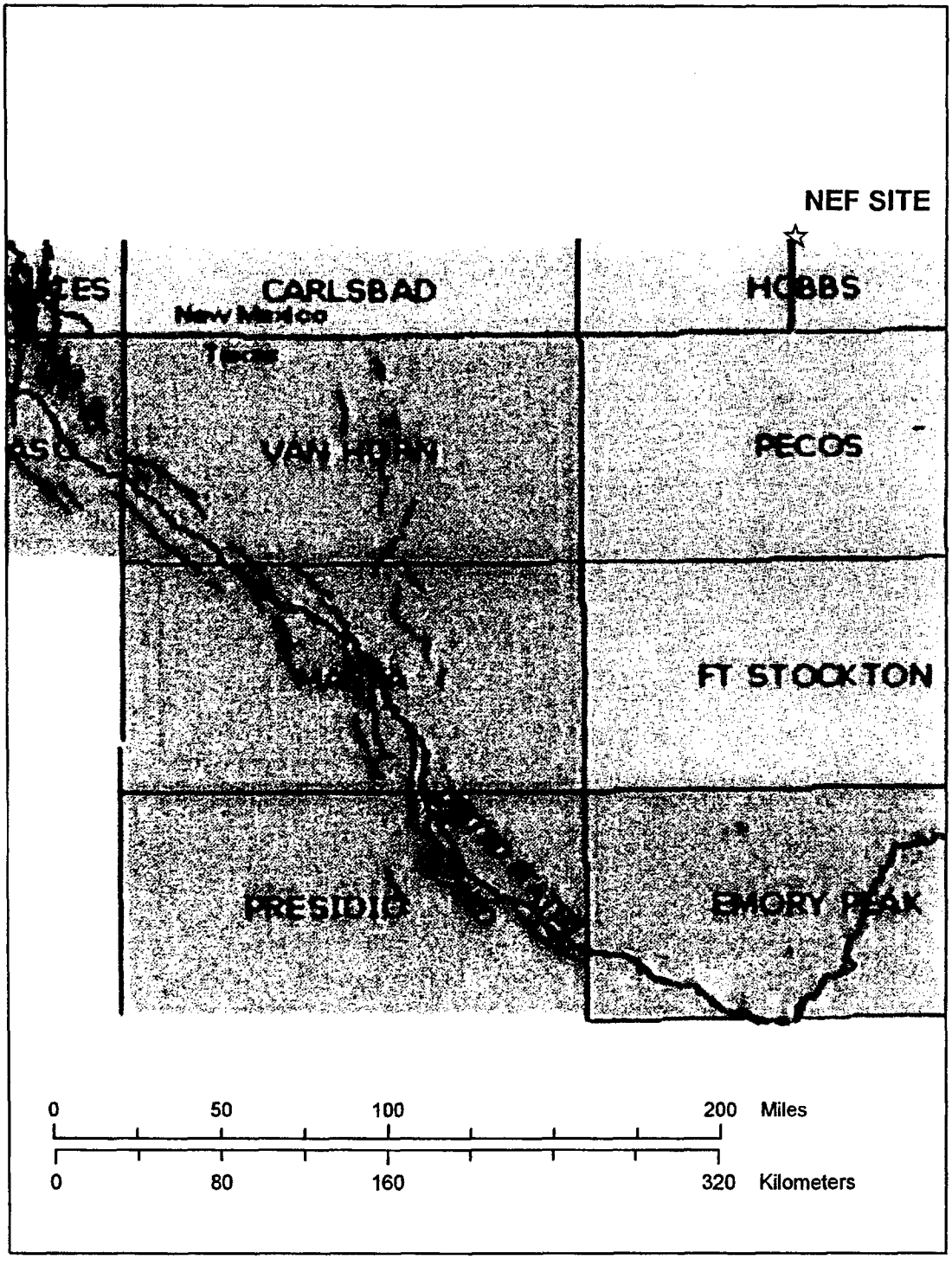


2

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

FIGURE 3.2-33
QUATERNARY FAULTS
IN NEW MEXICO

REVISION 2 DATE: JULY 2004

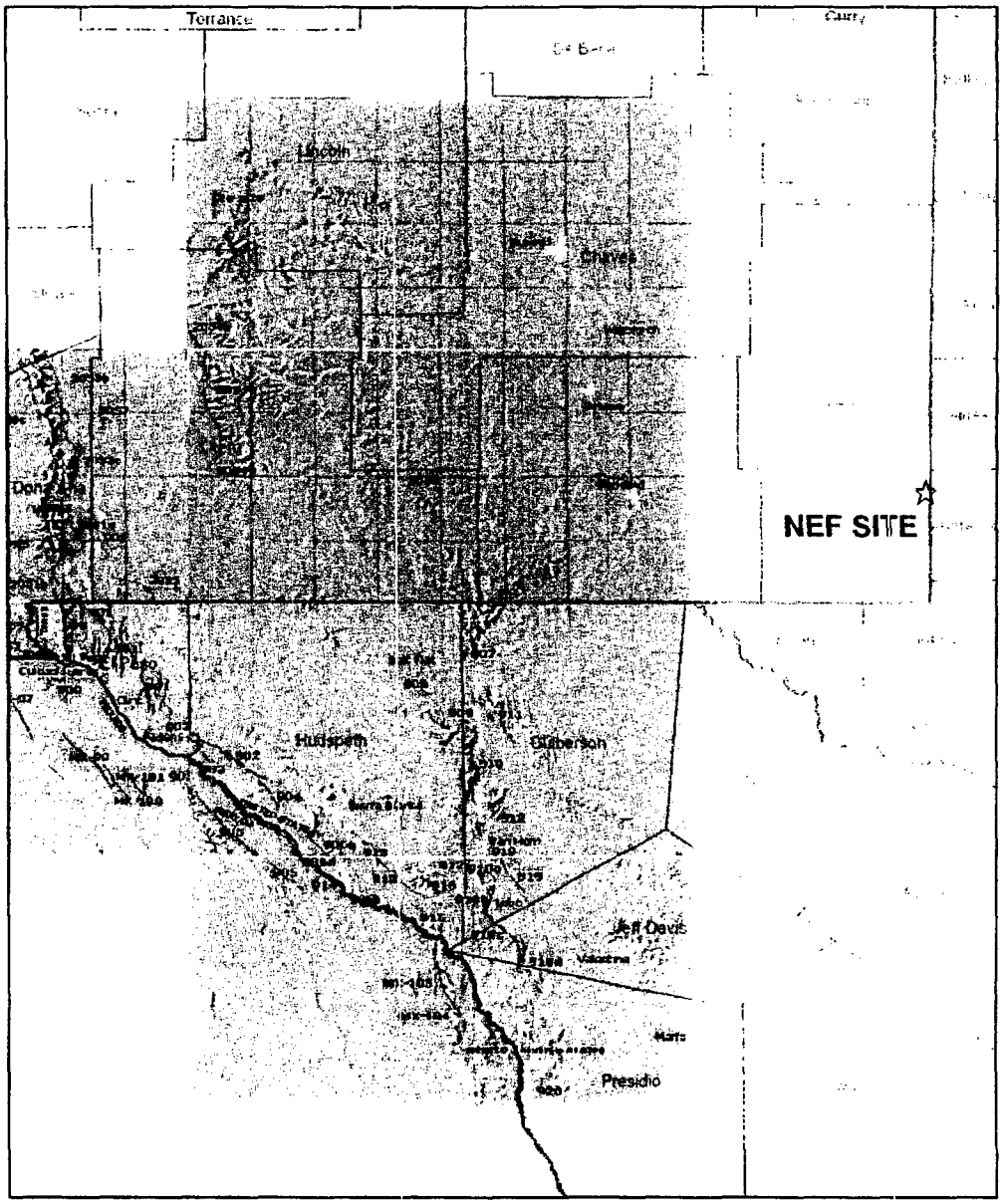


2

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

FIGURE 3.2-34
QUATERNARY FAULTS IN TEXAS

REVISION 2 DATE: JULY 2004



0 50 100 200 Miles

0 80 160 320 Kilometers

SOURCE: USGS, 2004; Machette, 2000

FIGURE 3.2-35

QUATERNARY FAULTS
WITHIN 322 km (200 mi) OF NEF SITE

REVISION 2 DATE: JULY 2004

0 50 100 200 Miles

0 80 160 320 Kilometers

NOTE: Locations of nearest capable faults (red traces) and older faults (blue traces)

FIGURE 3.2-36

LOCATIONS OF NEAREST FAULTS TO THE NEF SITE

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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

The overall layout of a Separations Building Module is presented in Figures 3.3-2 through 3.3-6. The facility includes three identical Separations Building Modules. Each module consists of two Cascade Halls, each of which houses a number of cascades connected in parallel producing a single product concentration at any one time. Each Cascade Hall is capable of producing 500,000 separative work units (SWU) per year. In addition to the Cascade Halls, each Separations Building Module houses a UF_6 Handling Area and a Process Services Area.

3.3.1.1.1 Design Description

Each Separations Building Module is approximately 170.0 m (557.75 ft) long x 67.9 m (222.75 ft) wide and 13.0 m (42.7 ft) high and totals 12,730 m^2 (137,025 ft^2), including both elevated floors of the Process Services Area. It is classified as a Special Purpose Industrial Occupancy area by the NFPA 101 (NFPA, 1997). It is classified as a Type I Unsprinklered Construction area by the New Mexico Building Code (NMBC, 1997) and as Type I Construction by NFPA 220 (NFPA, 1999). The thermal enclosure surrounding each assay (centrifuge) shall be constructed of and insulated with non-combustible materials (and is considered a fire barrier addressed by IROFS35).

Several chemical traps on the second floor of the Process Services Area contain hazardous materials. The chemical traps are housed in fire rated enclosures to meet the requirements of Section 6.4 of NFPA 101 (NFPA, 1997). The Separations Building Modules are designed to meet the occupant and exiting requirements set by NFPA 101 (NFPA, 1997) and to meet the construction type classifications set by the New Mexico Building Code (NMBC, 1997). The construction type and occupancy classification allow the Separations Building Modules to be unsprinklered. The UF_6 Handling Areas are separated from the Cascade Halls by one-hour fire-rated construction. The Separations Building Modules are also separated from each other by one-hour fire-rated construction.

3.3.1.1.2 Functional Areas and Major Components

3.3.1.1.2.1 Cascade Halls

Each Cascade Hall contains eight cascades. The centrifuges are mounted on precast.concrete floor mounting elements (flomels). Each Cascade Hall is enclosed by a structural steel frame, which is supporting insulated sandwich panels. This cascade enclosure surrounds each Cascade Hall to aid in maintaining a constant temperature within the cascade enclosure. This enclosure will also be constructed to have a minimum one hour fire-resistive rating.

3.3.1.1.2.2 Process Services Area

The Process Services Area contains the gas transport equipment, which connects the cascades to the UF_6 Feed System, the Product Take-off System, the Tails Take-off System and the Contingency Dump System.

The first floor of the Process Services Area, at elevation 1,040 m (3,415 ft) mean sea level (msl), contains various pieces of equipment, control cabinets and electrical cabinets. The second floor of the Process Services Area, at elevation 1,045 m (3,431.5 ft) msl, contains various pieces of equipment, control cabinets, electrical cabinets, valve support frames, process pumps and chemical traps. The third floor of the Process Services Area at elevation 1,049 m (3,444.5 ft) msl, contains various pieces of equipment, control cabinets, electrical cabinets, water pumps and heating and ventilation equipment. The various floors of the Process Services Area can be accessed by one of three stairways or by the elevator.

A. UF_6 Handling Area

The UF_6 Handling Area contains the UF_6 Feed System, the Product Take-off System, and the Tails Take-off System. The UF_6 Handling Area is approximately 43.3 m (142 ft) x 67.9 m (222.75 ft) and totals 2940 m^2 (31,646 ft^2).

Rail transporters travel on rails embedded in the floor along the entire length of the facility. The rail transporter moves the cylinders to and from the appropriate feed or receiver stations. It has the ability to handle both the 48-inch feed cylinders and UBCs and 30-inch or 48-inch product cylinders.

3.3.1.1.2.3 Building Construction

Each Separations Building Module superstructure is structurally independent from the rest of the facility and is designed to be missile resistant. The superstructure is of precast/prestressed concrete construction using rectangular columns, rectangular and inverted tee beams, double or single tee roof and floor members and solid wall panels.

The roof structure over the Separations Building Module consists of deep precast/prestressed concrete double or single tee members covered with a thin layer of isocyanurate insulation board, which provides a barrier between the concrete surface and the single-ply roof membrane. The single ply membrane is then covered by 100 mm (4 in) of dow board insulation, filter fabric and concrete pavers. The tee members are supported by concrete 'L' girders around the perimeter and inverted tee girders on interior spans. These will, in turn, be supported by

concrete columns supported on concrete spread footings. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls are precast insulated concrete panels. These walls will act as shear walls to provide lateral support for the structure. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is smooth concrete, which has been sealed and painted.

Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy 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 ACI 117-90 (ACI, 1990a) to aid in the transport of assembled centrifuges.

Floors in the Cascade Halls and UF_6 Handling Areas are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.2 Technical Services Building

The overall layout of the Technical Services Building (TSB) is presented in Figures 3.3-7 through 3.3-9. The TSB is located between column lines 1 and 11 and column lines N.1 and W, adjacent to the Blending and Liquid Sampling Area. The TSB contains support areas for the facility. It also acts as the secure point of entry to the Separations Building Modules and the Cylinder Receipt and Dispatch Building (CRDB).

3.3.1.2.1 Design Description

The TSB is a two-story structure, 10.0 m (32.8 ft) in height and totals 9,192 m^2 (98,942 ft^2). It is classified as a Special Purpose Industrial Occupancy area by NFPA 101 (NFPA, 1997). The TSB is classified as a Type I Unsprinklered Construction area by the New Mexico Building Code (NMBC, 1997) and as Type I Construction by NFPA 220 (NFPA, 1999). The TSB is designed to meet the occupant and exiting requirements set by the NFPA 101 (NFPA, 1997) and to meet the construction type classifications set by the New Mexico Building Code (NMBC, 1997). Several areas of the TSB have hazardous materials in quantities less than exempt amounts and are separated from areas by one-hour fire-rated construction. These areas include:

- Solid Waste Collection Room
- Vacuum Pump Rebuild Workshop
- Decontamination Workshop
- Ventilated Room.

Several of the TSB areas are separated from adjacent areas by one-hour fire-rated construction. These areas include:

- Liquid Effluent Collection and Treatment Room
- TSB GEVS Room
- Sample Storage Room which is located in the Chemical Lab.

3.3.1.2.2 Functional Areas and Major Components

3.3.1.2.2.1 Solid Waste Collection Room

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, high efficiency particulate air (HEPA) filters, scrap metal and miscellaneous hazardous materials.

This room is approximately 15.0 m (49.25 ft) x 20.0 m (65.6 ft) x 5.0 m (16.4 ft) high and totals 300 m^2 (3,229 ft^2). It is classified as a Special Purpose Industrial Occupancy area with a less than exempt amount of hazardous materials. This area is separated from the other Special Purpose Industrial Occupancy areas by one-hour fire-rated construction.

3.3.1.2.2.2 Vacuum Pump Rebuild Workshop

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 is approximately 12.8 m (42 ft) x 20.0 m (65.6 ft) x 5.0 m (16.4 ft) high and contains 256 m^2 (2,756 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), local extract systems, vacuum systems and a spray booth with a filter and extraction system. It is classified as a Special Purpose Industrial Occupancy area with a less than exempt amount of hazardous materials. This area is separated from the other Special Purpose Industrial Occupancy areas by one-hour fire-rated construction.

3.3.1.2.2.3 Decontamination Workshop

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, Fomblin 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 System 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 surrounding areas. Therefore any equipment or personnel entering this room must go through an air-lock.

This room is approximately 22.1 m (72.5 ft") x 20.0 m (65.6 ft) x 5.0 m (16.4 ft) high and contains 442 m^2 (4,758 ft^2). It is classified as a Special Purpose Industrial Occupancy area with a less than exempt amount of hazardous materials. This area is separated from the other Special Purpose Industrial Occupancy areas by one-hour fire-rated construction.

3.3.1.2.2.4 Ventilated Room

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 surrounding areas. Therefore, any equipment or personnel entering this room must go through an air-lock.

This room is approximately 14.9 m (48.9 ft) x 20.0 m (65.6 ft) x 5.0 m (16.4 ft) high and contains 298 m^2 (3,208 ft^2). It is classified as a Special Purpose Industrial Occupancy area with a less than exempt amount of hazardous materials. This area is separated from the other Special Purpose Industrial Occupancy areas by one-hour fire-rated construction.

3.3.1.2.2.5 Cylinder Preparation Room

The Cylinder Preparation Room is designed for the purpose of testing and inspecting new or cleaned 30B, 48X, and 48Y cylinders for use in the facility.

This room is approximately 25.0 m (82 ft) x 20.0 m (65.6 ft) x 10 m (32.8 ft) high and totals 500 m^2 (5,382 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

The Cylinder Preparation Room is maintained at a lower pressure than surrounding areas. Therefore any equipment or personnel entering this room must go through an air-lock.

3.3.1.2.2.6 Mechanical, Electrical and Instrumentation (ME&I) Workshop

The ME&I Workshop is designed to provide space for the normal maintenance of non-contaminated plant equipment. The facility also deals with faults associated with the pump motors, all instrument and control equipment, lighting, power, and associated process and services pipe work. It also provides space for the temporary storage of rebuilt equipment and other minor plant equipment.

This room is approximately 14.8 m (48.6 ft) x 20.0 m (65.6 ft) x 10.0 m (32.8 ft) high and totals 296 m^2 (3,186 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.7 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, laundry effluent water, 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.

This room is approximately 19.8 m (64.9 ft) x 20.0 m (65.6 ft) x 10.0 m (32.8 ft) high and totals 396 m^2 (4,263 ft^2). It is classified as a Special Purpose Industrial Occupancy area. The Liquid Effluent Collection and Treatment Room is separated from adjacent areas by one-hour fire-rated construction.

3.3.1.2.2.8 Laundry

The Laundry is designed to clean contaminated and soiled clothing and other articles, which have been used throughout the facility. Laundry is sorted into two categories, articles with a high possibility of contamination and articles unlikely to have been contaminated. Those that are likely to be contaminated are further sorted into lightly and heavily soiled articles. Heavily soiled articles are transferred to the solid waste disposal system without having been washed.

The Laundry contains two industrial quality washing machines (75 kg (165 lb) capacity), two industrial quality dryers (75 kg (165 lb) capacity), one sorting hood to draw potentially contaminated air away, a sorting table and an inspection table. The Laundry System is described in Section 3.5.16, Laundry System. The Laundry also contains a small office and storage room.

This room is approximately 161.2 m^2 (1,735 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.9 TSB Gaseous Effluent Vent System (GEVS) Room

The TSB GEVS is designed to remove UF_6, particulates containing uranium, and hydrogen fluoride (HF) from potentially contaminated process gas streams. Prefilters and High Efficiency Particulate Air filters remove particulates, including uranium particles, and impregnated and activated charcoal filters remove any residual traces of uranium and HF. The TSB GEVS is described in Section 3.4.9, Gaseous Effluent Vent System. The major components of the TSB GEVS are located in the TSB GEVS Room.

This room is approximately 9.6 m (31.5 ft) x 20.0 m (65.6 ft) x 10.0 m (32.8 ft) high and totals 192 m^2 (2,067 ft^2). It is classified as a Special Purpose Industrial Control area and is separated from the other Special Purpose Industrial Occupancy areas by one-hour fire-rated construction.

3.3.1.2.2.10 Mass Spectrometry Laboratory

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 is approximately 10.3 m (33.75 ft) x 20.0 m (65.6 ft) and totals 206 m^2 (2,217 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.11 Chemical Laboratory

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.

This room is approximately 16.2 m (53.2 ft) x 20.0 m (65.6 ft) and totals 324 m^2 (3,488 ft^2). It is classified as a Special Purpose Industrial Occupancy area. The Sample Storage Room in the Chemical Laboratory is one-hour fire-rated construction.

3.3.1.2.2.12 Environmental Monitoring Laboratory

The Environmental Monitoring Laboratory is designed for the purpose of preparing and analyzing samples associated with safety or regulatory compliance.

This room and associated office space are approximately 17.3 m (56.75 ft) x 19.3 m (63.3 ft) and totals 334 m^2 (3,595 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.13 Truck Bay/Shipping and Receiving Area

The Truck Bay is 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 room is approximately 4.6 m (15.08 ft) x 9.8 m (32.2 ft) and totals 45 m^2 (484 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.14 Medical Room

The Medical Room is designed to provide space for a nurse's station. This room is approximately 5.2 m (17 ft) x 5.4 m (17.75 ft) and totals 28 m^2 (301 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.15 Radiation Monitoring Control Room

The Radiation Monitoring Control Room 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 is approximately 3.65 m (12 ft) x 8.4 m (27.6 ft) and totals 30 m^2 (323 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.16 Break Room

The Break Room has room for vending machines, tables and a small kitchenette. It also serves as an assembly area for emergency planning purposes and has area allocated for the storage of emergency equipment and supplies and emergency monitoring equipment.

This room is approximately 7.3 m (23.9 ft) x 15.0 m (49.25 ft) and totals 110 m^2 (1,184 ft^2). It is classified as a Special Purpose Industrial Occupancy area.

3.3.1.2.2.17 Control Room

The Control Room and associated support area are approximately 14.4 m (47.25 ft) x 12.6 m (41.3 ft) and totals 181 m^2 (1,948 ft^2) and is the main monitoring point for the entire facility. It is classified as a Special Purpose Industrial Occupancy area. The Control Room provides all of the facilities for the control of the plant, operational requirements and personnel comfort. It is a permanently manned area and contains the following equipment:

- Overview screen
- Control desk
- Fire alarm system
- Storage facilities
- 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.

3.3.1.2.2.18 Training Room

The Training Room and associated support area are approximately 9.7 m (31.8 ft) x 10.6 m (34.75 ft) and totals 103 m^2 (1,108 ft^2) and is used for Control Room training. It is classified as a Special Purpose Industrial Occupancy area. It has visual and personnel access to the Control Room and contains the following:

- Plant Control System training system
- Centrifuge Monitoring System training system
- Central Control System switches and servers.

3.3.1.2.2.19 Security Alarm Center

The Security Alarm Center is approximately 7.0 m (23 ft) x 5.6 m (18.3 ft) and totals 39 m^2 (420 ft^2) and is used as the primary security monitoring station for the facility. It is classified as a Special Purpose Industrial 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.

3.3.1.2.3 Building Construction

The TSB superstructure is of precast/prestressed concrete construction using rectangular columns, rectangular and inverted tee beams, double or single tee roof and floor members and solid wall panels.

The roof structure over the TSB consists of deep precast/prestressed concrete double or single tee members covered with a thin layer of isocyanurate insulation board that provides a barrier between the concrete surface and the single-ply roof membrane. The single ply membrane is then covered by 100 mm (4 in) of dow board insulation, filter fabric and concrete pavers. The tee members are supported by concrete 'L' girders around the perimeter and inverted tee girders on interior spans. These, in turn, are supported by concrete columns supported on concrete spread footings. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls are precast insulated concrete panels. These walls act as shear walls to provide lateral support for the structure. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is of smooth concrete that has been sealed and painted. Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy painted finish. These walls extend to the underside of the structure where required.

Floors in the TSB technical areas are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.3 Cylinder Receipt and Dispatch Building (CRDB)

The overall layout of the CRDB is presented in Figures 3.3-10 through 3.3-12. The CRDB is located between two Separations Building Modules, adjacent to the Blending and Liquid Sampling Area.

3.3.1.3.1 Design Description

The CRDB is approximately 45.9 m (150.6 ft) wide x 246.2 m (807.75 ft) long and 13.0 m (42.7 ft) high and totals 11,300 m^2 (121,638 ft^2). The entire CRDB is open to the underside of the roof. It is classified as a Storage Occupancy area by the NFPA 101 (NFPA, 1997). It is classified as a Type I Unsprinklered Construction area by the New Mexico Building Code (NMBC, 1997) and as Type I Construction by NFPA 220 (NFPA, 1999). The CRDB is designed to meet the occupant and exiting requirements set by the NFPA 101 (NFPA, 1997) and to meet the construction type classification set by the New Mexico Building Code (NMBC, 1997). The CRDB is separated from the separations modules and Blending and Liquid Sampling Area by one-hour fire-rated construction. The CRDB exterior walls are a minimum one-hour fire-rated construction.

3.3.1.3.2 Functional Areas and Major Components

All UF_6 feed cylinders and empty product cylinders and uranium byproduct cylinders (UBCs) enter the facility through the CRDB. It is designed to include space for the following:

- Loading and unloading of cylinders
- Inventory weighing
- Buffer storage of feed cylinders
- Preparation and storage of overpack protective packaging
- Semi-finished product storage
- Final product storage
- Prepared cylinder storage.

The majority of the floor area is used as lay-down space for the cylinders, for both storage and preparation. The cylinders are placed on specially designed cradles called stillages 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 between column lines 40 and 41, which is equipped with vehicle access platforms that aid with cylinder loading and unloading. Two double girder bridge cranes handle the cylinders within the CRDB. Each crane spans 1/2 the width and runs the full length of the building.

After delivery, the cylinders are processed for receipt as either empty UBCs (48-in cylinders) or empty product cylinders (30-in or 48-in cylinders) or UF_6 feed cylinders (48-in cylinders). They are inspected and weighed and moved to their appropriate locations. UF_6 feed cylinders are delivered to a storage area in the CRDB.

When required for processing, the cylinders, which have been placed in storage areas are moved by the overhead cranes to the rail transporter located between column lines 15.4 and 16 of the CRDB. The CRDB rail transporter transports cylinders to the main rail transporter in the Blending and Liquid Sampling Area, which then delivers the cylinders to their required locations throughout the facility. Cylinders are removed from the facility in the same fashion.

3.3.1.3.3 Building Construction

The CRDB superstructure is designed to be missile resistant and is of precast/prestressed concrete construction using rectangular columns, rectangular and inverted tee beams, double or single tee roof and floor members and solid wall panels.

The two double girder bridge cranes are supported by a steel girder crane runway, supported by the precast concrete columns.

The roof structure over the CRDB consists of deep precast/prestressed concrete double or single tee members covered with a thin layer of isocyanurate insulation board that provides a barrier between the concrete surface and the single-ply roof membrane. The single ply membrane is then covered by 100 mm (4 in) of dow board insulation, filter fabric and concrete pavers. The tee members are supported by concrete 'L' girders around the perimeter and inverted tee girders on interior spans. These, in turn, are supported by concrete columns

supported on concrete spread footings. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls are precast insulated concrete panels. These walls act as shear walls to provide lateral support for the structure. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is smooth concrete, which has been sealed and painted. Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy painted finish. These walls extend to the underside of the structure where required.

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 ACI 117-90 (ACI, 1990a) to aid in the transport of assembled centrifuges.

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

The overall layout of the Centrifuge Assembly Building (CAB) is presented in Figures 3.3-13 through 3.3-16. The Centrifuge Assembly Building is located adjacent to the Cylinder Receipt and Dispatch Building.

3.3.1.4.1 Design Description

The CAB is approximately 50.9 m (167 ft) wide x 195.5 m (641.4 ft) long and ranges from 11 m (36.08 ft) to 16 m (52.5 ft) high. It totals approximately 11,364 m^2 (122,322 ft^2). The entire CAB is open to the underside of the roof. It is classified as a Special Purpose Industrial Occupancy area by NFPA 101 (NFPA, 1997). It is classified as a Type I Unsprinklered Construction area by the New Mexico Building code (NMBC, 1997). The CAB is designed to meet the occupant and exiting requirements set by NFPA 101 (NFPA, 1997) and to meet the construction type classifications set by the New Mexico Building code (NMBC, 1997) and as Type I Construction by NFPA 220 (NFPA, 1999). The CAB is separated from the CRDB one-hour fire-rated construction.

The Centrifuge Assembly Building is used for the assembly, inspection and mechanical testing of the centrifuges prior to installation in the Cascade Halls of the Separations Building Modules and introduction of UF_6. Centrifuge assembly operations are undertaken in clean room conditions. The building is divided into the following distinct areas:

- Centrifuge Component Storage Area
- Centrifuge Assembly Area 'A'
- Centrifuge Assembly Area 'B'
- Assembled Centrifuge Storage Area
- Building Office Area
- Centrifuge Test and Post Mortem Facilities.

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 delivered from Europe. 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 end of the CAB.

Because the assembly operations are undertaken in clean room conditions, the centrifuge component containers are cleaned in a washing facility located within the Centrifuge Component Storage Area, prior to admission to the Centrifuge Assembly Area. The Centrifuge Component Storage Area also 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 Area is via an airlock to prevent ingress of airborne contaminants.

3.3.1.4.2.2 Centrifuge Assembly Area

Centrifuge components are assembled into complete centrifuges in this area. Assembly operations are carried out on two parallel production lines, A and B.

The centrifuge operates in a vacuum, therefore, centrifuge assembly activities are undertaken in clean room conditions, ISO Class 5 according to ISO 14644-1:1999E (ISO, 1999), to prevent ingress of volatile contaminants which would have a detrimental effect on centrifuge performance. Prior to installation into the cascade, the centrifuge has to be conditioned, which is done in the Centrifuge Assembly Area prior to storage in the Assembled Centrifuge Storage Area.

Local jib cranes are installed in certain areas and impose less than a 500 kg (1100 lb) load. The Centrifuge Assembly Area is separated from other areas by one-hour fire-rated construction.

3.3.1.4.2.3 Assembled Centrifuge Storage Area

Assembled and conditioned centrifuges are stored in the Assembled Centrifuge Storage Area prior to installation.

During construction of the facility, a separate installation team will access this area and transfer the assembled and conditioned centrifuges to the Cascade Halls for deployment.

Centrifuges are routed via a covered corridor that links the Assembled Centrifuge Storage Area with the CRDB. The covered corridor has the same standard of floor as the Assembled Centrifuge Storage Area.

3.3.1.4.2.4 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
- Change Rooms - The change rooms provide space where employees can dress in protective clothing as required
- Break Room
- Maintenance Area
- Chemical Storage Area
- Battery Charging Area.

3.3.1.4.2.5 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.

This area consists of two test positions. 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 to the TSB prior to disposal.

Centrifuges are brought into the facility on a specially designed transport cart via an airlock entry. 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 superstructure is designed of precast/prestressed concrete construction using rectangular columns, rectangular and inverted tee beams, double or single tee roof and floor members and solid wall panels.

The roof structure over the CAB consists of deep precast/prestressed concrete double or single tee members covered with a thin layer of isocyanurate insulation board that provides a barrier between the concrete surface and the single-ply roof membrane. The single ply membrane is then covered by 100 mm (4 in) of dow board insulation, filter fabric and concrete pavers. The tee members are supported by concrete 'L' girders around the perimeter and inverted tee girders on interior spans. These will, in turn, be supported by concrete columns supported on concrete spread footings. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls are precast insulated concrete panels. These walls act as shear walls to provide lateral support for the structure. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is smooth concrete that has been sealed and painted.

Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy painted finish. These walls extend to the underside of the structure where required.

The floors of the CAB Assembled Centrifuge Storage Area have a floor profile quality classification of flat in accordance with ACI 117-90 (ACI, 1990a) to aid in the transport of assembled centrifuges.

Floors in the CAB are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

The Centrifuge Test Facility Area is separated from other areas by one-hour fire-rated construction.

3.3.1.5 Blending and Liquid Sampling Area

The Blending and Liquid Sampling Area is shown in Figure 3.3-17. The Blending and Liquid Sampling Area is adjacent to the CRDB and is located between two Separations Building Modules.

3.3.1.5.1 Design Description

The Blending and Liquid Sampling Area is approximately 45.9 m (150.6 ft) wide x 33.5 m (109.9 ft) long and 10.0 m (32.8 ft) high and totals 1,538 m^2 (16,555 ft^2). The entire area is open to the underside of the roof. It is classified as a Special Purpose Industrial Occupancy area by NFPA 101 (NFPA, 1997). It is classified as a Type I Unsprinklered Construction area by the New Mexico Building code (NMBC, 1997) and as Type I Construction by NFPA 220 (NFPA, 1999). The Blending and Liquid Sampling Area is designed to meet the occupant and exiting requirements set by the NFPA 101 (NFPA, 1997) and to meet the construction type classification set by the New Mexico Building code (NMBC, 1997). The Blending and Liquid Sampling Area is separated from the UF_6 Handling Areas by one-hour fire-rated construction.

3.3.1.5.2 Functional Areas and Major Components

The primary function of the Blending and Liquid Sampling Area is to provide means to fill 30B cylinders with UF_6 at a required ^{235}U concentration level and to obtain samples of the homogenized liquid UF_6. The area 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.

3.3.1.5.3 Building Construction

The Blending and Liquid Sampling Area superstructure is designed to be missile resistant and is of precast/prestressed concrete construction using rectangular columns, rectangular and inverted tee beams, double or single tee roof and floor members and solid wall panels.

The roof structure over the Blending and Liquid Sampling Area consists of deep precast/prestressed concrete double or single tee members covered with a thin layer of isocyanurate insulation board that provides a barrier between the concrete surface and the single-ply roof membrane. The single ply membrane is then covered by 100 mm (4 in) of dow board insulation, filter fabric and concrete pavers. The tee members are supported by concrete 'L' girders around the perimeter and inverted tee girders on interior spans. These, in turn, are supported by concrete columns supported on concrete spread footings. The roof assembly has a minimum combined thermal resistance value of R-20.

Exterior walls are precast insulated concrete panels. These walls act as shear walls to provide lateral support for the structure. The exterior wall assembly has a minimum combined thermal resistance value of R-10. The interior side of the exterior wall is smooth concrete, which has been sealed and painted.

Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy painted finish. These walls extend to the underside of the structure where required.

Floors in the Blending and Liquid Sampling Area are of exposed concrete with a washable epoxy coating finish. The coatings are designed to resist process chemicals, decontamination agents and radiation.

3.3.1.6 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 to store empty feed cylinders that are not immediately reconnected to the facility. 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 six months of empty feed cylinders. Approximately 625 UBC per year are filled for storage. The UBC Storage pad is sized to accommodate 15,727 cylinders (capacity equivalent to 30 years of facility operation).

These cylinders are stacked two high. Concrete saddles are used to store the cylinders approximately 200 mm (8 in) above ground level. The UBC Storage Pad occupies approximately 8.50 ha (21 acres).

3.3.1.6.2 Functional Areas and Major Components

The UBC Storage Pad layout is based on moving the cylinders with cranes and flatbed trucks. Flatbed trucks are used to move the cylinders from the CRDB to the UBC Storage Pad. A double girder Gantry crane is used to remove the cylinders from the flatbed trucks and place them in the UBC Storage Pad. The Gantry crane is designed to double stack the cylinders in the storage area.

3.3.1.6.3 Construction

The UBC Storage Pad is constructed of a concrete pad with a dedicated collection and drainage system. Vehicle crash barriers are located along the site roads outside of the Controlled Access Area adjacent to the storage area. The entire area is fenced for security and radiological protection purposes.

3.3.1.7 Central Utilities Building

The Central Utilities Building (CUB) is shown on Figure 3.3-18.

3.3.1.7.1 Design Description

The CUB is approximately 24.8 m (81.3 ft) wide x 80.8 m (265.08 ft) long and 10 m (32.8 ft) high and totals 1962 m^2 (21,119 ft^2). It is classified as a Special Purpose Industrial Occupancy by NFPA 101 (NFPA, 1997). It is classified as a Type IIIN Unprotected, Sprinklered Construction area by the New Mexico Building Code (NMBC, 1997) and as Type II Construction by NFPA 220 (NFPA, 1999). The Central Utilities Building is designed to meet the occupant and exiting requirements set by the NFPA 101 (NFPA, 1997) and set by the New Mexico Building Code (NMBC, 1997).

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, by roll-up and access doors.

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 cooling water chillers and pumps, boiler room, hot water boilers and pumps, deionized water systems and air compressors. These systems are described in Sections 3.5.5, Cooling Water System, 3.5.4, Water Supply, and 3.5.3, Compressed Air System, respectively.

3.3.1.7.3 Building Construction

The Central Utilities 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 metal panel system. The exterior wall assembly has a minimum combined thermal resistance value of R-10.

Interior non-load bearing walls are constructed of 200 mm (8 in) concrete block with an epoxy painted finish. These 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 Administration Building

3.3.1.8.1 Design Description

The Administration Building is near the TSB. It is approximately 1403 m^2 (15,102 ft^2) and 6.0 m (19.8 ft) high. It is classified as a New Business Occupancy area by the NFPA 101 (NFPA,1997) and is classified as a Type IIIN Unprotected Construction area by the New Mexico Building Code (NMBC, 1997) and as Type II Construction by NFPA 220 (NFPA, 1999). The Administration Building is designed to meet the occupant, and exiting requirements set by the NFPA 101 (NFPA,1997) and by the New Mexico Building Code (NMBC, 1997). The entire building is sprinklered.

3.3.1.8.2 Functional Areas and Major Components

The general office areas and the Entry Exit Control Point (EECP) for the facility are located in the Administration 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 enter the Administration Building and general office areas via the main lobby.

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 Administration Building is only possible through the EECP.

Approximately 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 Visitor Center

A Visitor Center is located outside of the security fence area.

3.3.1.10 Site Security Buildings

3.3.1.10.1 Design Description

The main Security Building is located at the entrance to the facility. It functions as a security checkpoint for incoming and outgoing traffic. Employees, visitors and trucks that have access approval are screened at the main building. A smaller security station has been placed at the secondary entrance to the site. Vehicle traffic including common carriers, such as mail delivery trucks, are screened at this location.

3.3.1.10.2 Functional Areas and Major Components

The main and secondary Security Buildings are located at the entries to the site. They are classified as a New Business Occupancy area by the NFPA 101 (NFPA, 1997) and is classified as Type IIIN Unprotected Construction area by the New Mexico Building Code (NMBC, 1997) and as Type II Construction by NFPA 220 (NFPA, 1999). These buildings are designed to meet the occupant and exiting requirements set by the NFPA 101 (NFPA, 1997) and the construction type classifications set by the New Mexico Building Code (NMBC, 1997).

3.3.1.10.3 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 combined thermal resistance value of R-20.

Exterior walls consist of a combination of architectural metal panels and glazing. 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.

Floors in the Security Buildings consist of sealed 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 discussed 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:

- Separations Building Modules (UF_6 Handling Area, Process Services Area, and Cascade Halls)
- Blending and Liquid Sampling Area
- Cylinder Receipt and Dispatch Building
- TSB
- Centrifuge Test Facility.

A. Safety significant structures shall be designed to withstand the effects of external events (i.e., seismic, tornado and high winds, tornado missiles, snow and ice load, and maximum local precipitation) reflected in Section 3.2.

B. The UF_6 Handling Area, Cascade Hall, Blending and Liquid Sampling Area, and Ventilated Room shall be designed and maintained such that leakage is maintained within the values determined in Integrated Safety Analysis (ISA) consequence calculations.

C. The UBC Storage Pad shall be designed to preclude flooding due to maximum local precipitation reflected in Section 3.2.

D. 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 Building Code (NMBC, 1997)
- Uniform Building Code (UBC, 1997)
- ASCE 7-98, Minimum Design Loads for Buildings and Other Structures (ASCE, 1998)
- ACI 318-99, Building Code Requirements for Structural Concrete (ACI, 1999)
- ACI 349-90, Code Requirements for Nuclear Safety Related Concrete Structures (ACI, 1990b)
- AISC Manual of Steel Construction, Ninth Edition (AISC, 1989)
- PCI Design Handbook, Fifth Edition (PCI, 1999)
- American Society of Testing and Materials (ASTM).

3.3.2.2 Structural Design Loads

3.3.2.2.1 Wind Loadings

The determination of wind pressure loadings and the design for wind loads for all safety significant structures and components exposed to wind are based on the requirements of ASCE 7-98 (ASCE, 1998). The determination of wind pressure loadings and the design for wind loads for all other structures and components exposed to wind are based on the requirements of the Uniform Building Code (UBC, 1997), Chapter 16 which further refers to the wind design requirements of ASCE 7-98, Section 6.0 (ASCE, 1998). The design wind for structures having no safety significance is based on a 50-year period of recurrence. The basic wind speed is 130 km/hr (80 mi/hr). The wind speed is based on an Exposure C category which is for open terrain

with scattered obstruction areas as given in the Uniform Building Code (UBC, 1997). For structures that are safety significant, the design wind speed is 252 km/hr (157 mi/hr). This wind speed is based on a 100,000-year period of recurrence. All buildings on the NEF site are less than 18.2 m (60 ft) in height.

The design wind pressures and forces on the total building area calculated in accordance with procedures outlined in Section 6.4.2 of ASCE 7-98 (ASCE, 1998). The wind pressures acting on the main wind-force resisting systems are determined using the following formulas:

Velocity Pressure $q_z = 0.00256 K_z K_{zt} K_d V^2 I$ (lb/ft^2) (Eq. 3.3-1)

Design Pressure $p = qGC_p - q_i(GC_{pi})$ (lb/ft^2) (Eq. 3.3-2)

Where:

q_z	=	velocity pressure evaluated at height z above ground, psf
K_z	=	velocity pressure exposure coefficient evaluated at height z
K_{zt}	=	topographic factor
K_d	=	wind directionality factor
V	=	basic wind speed, mi/hr (corresponds to a 3-second gust speed at 10.1 m (33 ft) in exposure category C)
I	=	importance factor = 1.00. Safety significant structures have an increased safety factor due to design probability of 1.0E-5 of wind
p	=	design wind pressure, lb/ft^2
G	=	gust effect factor
C_p	=	external pressure coefficient
q_i	=	velocity pressure for internal pressure determination
GC_{pi}	=	product of internal pressure coefficient and gust factor

The design of wind pressures and forces on building components and cladding are calculated in accordance with procedures outlined in Section 6.5.12.4 of ASCE 7-98 (ASCE, 1998). Wind pressures on building components and cladding are determined using the following formula:

$p = q_h[(GC_p) - (GC_{pi})]$ (lb/ft^2) (Eq. 3.3-3)

Where:

p	=	design wind pressure, lb/ft^2
q_h	=	velocity pressure at roof height z = h (mean roof height), lb/ft^2
G	=	gust effect factor
C_p	=	external pressure coefficient
GC_{pi}	=	product of internal pressure coefficient and gust factor

The design wind pressure on other structures is calculated in accordance with procedures outlines in Chapter 16, Division III of the Uniform Building Code (UBC, 1997). The design wind pressure is determined using the following formula:

Design Pressure $P = C_e C_q q_s I_w$ (lb/ft^2) (Eq. 3.3-4)

Where:

C_e = combined height, exposure and gust factor coefficient from Table 16-G

C_q = pressure coefficient from Table 16-H

q_s = wind stagnation pressure at standard height of 10 m (33 ft)

I_w = wind importance factor from Table 16-K Occupancy Category

The design wind pressures and forces on the total building area calculated in accordance with procedures outlined in Section 1621.3 of the Uniform Building Code (UBC, 1997). The design of wind pressures and forces on building components and cladding are calculated in accordance with procedures outlined in Section 1622 of the Uniform Building Code (UBC,1997).

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 wind pressures are determined and applied to the structures and buildings in the same manner as the wind loads described in Section 3.3.2.2.1, Wind Loadings. Internal pressure differential due to atmospheric pressure change is considered. 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 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. 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 Separations Building 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 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 (t_s) are based on the Modified National Defense Research Committee Formula (NDRC) (ASCE, 1980) and the Army Corps of Engineers Formula (ACE) (ASCE, 1980) 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.7.2.2 of ACI 349-90 (ACI, 1990b), 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 349-90 (ACI, 1990b), Section C.7.2.3.

For steel targets, the formula used to establish the perforation thickness is the Ballistic Research Laboratory (BRL) Formula (ASCE, 1980).

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.

$$D = \frac{W}{d^3} = \text{missile caliber density, lbs/in}^3$$

$$d = \left(\frac{4A_c}{\pi}\right)^{\frac{1}{2}} = \text{effective missile diameter, in.}$$

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, 1980, 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. Various methods for designing to resist the overall effects of missile impact are available. In addition to the procedure outlined below, the different formulations as presented in ACI 349-90 (ACI, 1990b) may be used.

The response of a structure to missile impact depends largely on the location of impact, the dynamic properties of the structure (target), and the kinetic energy of the missile. For tornado-generated missiles, the assumption of a plastic collision between the missile and target is used where all of the missile momentum is transferred into the target. Based on this assumption, and that the target has elasto-plastic behavior, expressions for an equivalent static load concentrated at the impact area can be determined (ASCE, 1980). This load, in combination with other design loads, is evaluated using conventional design methods.

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 high point of finished grade elevation and all roads are set at least 0.45 m (1.5 ft) below this. In addition, in order to prevent general site flooding from the contributory areas above the site, an earth berm and 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.

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 Chapter 16, Division IV of the Uniform Building Code (UBC, 1997). 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. Based on Figure 16-2, Seismic Zone Map of the United States, the NEF site is located in seismic zone 1.

Although much of the facility is of a critical nature, the additional safety factor for developing seismic forces for these structures is provided by using the occurrence probability of 10^{-4}. Based on this, all buildings will be taken as standard occupancy structures.

The seismic total design base shear in a given direction is determined by the following:

$$V = \frac{C_v I}{RT} W \qquad \text{(Eq. 3.3-9)}$$

The total design base shear need not exceed:

$$V = \frac{2.5 C_a I}{R} W \qquad \text{(Eq. 3.3-10)}$$

The total design base shear shall not be less than:

$$V = 0.11 C_a I W \qquad \text{(Eq. 3.3-11)}$$

Where:

V = Total design lateral force or base shear

C_a = Seismic coefficient, as set forth in Table 16-Q of the Uniform Building Code (UBC, 1997)

C_v = Seismic coefficient, as set forth in Table 16-R of the Uniform Building Code (UBC, 1997)

R = Numerical coefficient representative of the inherent overstrength and global ductility capacity of lateral-force-resisting systems as set forth in Table 16-N or 16-P of the Uniform Building Code (UBC, 1997)

I = Importance factor, as set forth in Table 16-K of the Uniform Building Code (UBC, 1997)

T = Elastic fundamental period of vibration, seconds

W = Total seismic dead load defined in Section 1630.1.1 of the Uniform Building Code (UBC, 1997)

3.3.2.2.5.2 Design Basis Earthquake

The Design Basis Earthquake (DBE) for the NEF site has a peak horizontal acceleration of 0.15g and peak vertical acceleration of 0.15g. These values correspond to a design basis earthquake with a return period of 10,000 years (1.0E-4 annual probability). The ultimate target performance goal is an annual probability of 1.0E-5. The difference between design and target performance is accounted for in the design process by confirmatory calculations (design will based on code allowables and safety factors, additional calculations will show that although these allowables are exceeded for the target performance goal, the ultimate capabilities will not be exceeded). For licensing purposes, 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

Snow loadings on roofs and other exposed surfaces for non-safety significant structures are determined in accordance with the Uniform Building Code (UBC, 1997), Chapter 16, Division II. The design parameters identified below are based on a mean return period of 50 years.

Snow loadings on roofs of safety significant buildings are based on a Ground Snow Load (p_a) of 156 kg/m^2 (32 lb/ft^2). Further discussion for the basis of this load can be found in Section 3.2. All other parameters and determination of snow drifts will be the same as the non-safety significant structures.

3.3.2.2.6.2 Rainfall Loadings

Rainfall loadings on roofs and other exposed surfaces result from two different events. The first event is normal heavy rainfall having a 100 year return period. Loads on the roof occur during this event as a result of assuming that the primary roof drains are blocked. The load equals the depth of water required before water can flow out of the secondary roof drains. The roof drainage systems (including secondary roof drains) will be designed such that the amount of rainfall that can collect on the roof does not exceed the normal roof design live load.

The second event is localized intense rainfall. Refer to Section 3.2.3.4.4 for further discussion. The load equals the depth of water that accumulates in excess of the roof drains capacity. This is used for the design of the safety significant areas only.

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.

3.3.2.2.7.1 Equipment Loads

All pieces of equipment that exceed 454 kg (1,000 lb) dead weight, including contents, are accounted for individually in the design. The remaining equipment is accounted for in the building design by including an appropriate uniform dead load for a particular area.

3.3.2.2.7.2 Piping Loads

Piping loads transmitted through pipe racks to the building are based on combined dead and live loads of 244 kg/m^2 (50 lb/ft^2) of pipe run area for each pipe rack level. The area considered is the length times the width of the pipe runs.

3.3.2.2.7.3 HVAC Loads

HVAC duct loads transmitted through supports to the building are based on combined dead and live loads of 146 kg/m^2 (30 lb/ft^2) of duct run area. The area considered is the length times the width of the HVAC duct runs.

3.3.2.2.7.4 Electrical Tray and Conduit Loads

Electrical tray and conduit loads transmitted through supports and electrical racks to the building are based on combined dead and live loads of 74 kg/m (50 lb/ft) of tray and a 91 kg (200 lb) concentrated load at mid-span of the tray and 30 kg/m (20 lb/ft) of conduit.

3.3.2.2.8 Combined Loadings for Structures

Load combinations for concrete structures and components for the safety significant structures are based on ACI 349-90 (ACI, 1990b). These combinations are listed in Section 3.3.2.2.8.3.1. Load combinations for other concrete structures are based on ASCE 7-98 (ASCE, 1998). These combinations are listed in Section 3.3.2.2.8.3.2. All concrete structures are designed using the ACI Strength Design Method (ACI, 1999). Load combinations for steel structures and components for all buildings are based on ASCE 7-98 (ASCE, 1998). These load combinations are listed in Section 3.3.2.2.8.3.3. All structural steel is designed using the AISC Allowable Stress Method (AISC, 1989). 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 L_R)

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 (SBCCI, 1999).

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 (E_o)

   Building code earthquake loads are discussed in Section 3.3.2.2.5, Seismic Loadings.

G. Process and Equipment Reactions (R_o)

Process and equipment derived loads are discussed in Section 3.3.2.2.7, Process and Equipment Derived Loadings.

H. Postulated Pipe Break Loads

1. Pressure Differential (Pa) - Differential pressure load generated by a postulated pipe break. Load to be determined during final design based on line size and maximum pressure.
2. Jet Impingement Load (Y_j) - Jet impingement load generated by a postulated pipe break. Load to be determined during final design based on line size and maximum pressure.
3. Missile Impact Load (Y_m) - Missile impact load, including pipe whip, generated by a postulated pipe break. Load to be determined during final design based on line size and maximum pressure.
4. Pipe Reaction (Y_r) - Load generated by broken pipe during postulated pipe break. Load to be determined during final design based on line size and maximum pressure.

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 (W_t)

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 (W_w)
2. Tornado induced differential pressure (W_p)
3. Tornado generated missile load (W_m)

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 ACI 349-90 (ACI, 1990b).

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 (E_s)

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 Area and Cascade Halls), Blending and Liquid Sampling Area, Cylinder Receipt and Dispatch Building, Technical Services Building and the Centrifuge Test Facility. As described in Section 3.3.1, Buildings and Major Components, these buildings and areas are constructed of concrete.

3.3.2.2.8.3 Combined Load Applications

The load combinations defined in this section are applied to all structures, components and equipment supports.

A. Load Combinations For Structures Combining Factored Loads Using Strength Design (Concrete)

All of the following load combinations shall be satisfied for concrete structures for the safety significant areas:

1. $U = 1.4D + 1.4F + 1.7(L_R \text{ or } S \text{ or } R) + 1.7H + 1.4R_o$
2. $U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7Eo + 1.7Ro$
3. $U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W + 1.7Ro$
4. $U = D + F + L + H + T + Ra + 1.25Pa$
5. $U = D + F + L + H + T + Ra + 1.15Pa + 1.0(Yr + Yj + Ym) + 1.15Eo$
6. $U = 1.05D + 1.05F + 1.3L + 1.3H + 1.05T + 1.3Ro$
7. $U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3Eo + 1.05T + 1.3Ro$
8. $U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3W + 1.05T + 1.3Ro$

For extreme environmental conditions the following load combinations are satisfied:

9. $U = D + F + L + H + T + R_o + E_s$
10. $U = D + F + L + H + T + R_o + W_t$
11. $U = D + F + L + H + T + R_a + 1.0P_a + 1.0(Y_r + Y_j + Y_m) + 1.0E_s$
12. 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 318 (ACI, 1999).

B. Load Combinations For Structures Combining Factored Loads Using Strength Design (Concrete)

All of the following load combinations shall be satisfied for all concrete structures:

1. $U = 1.4(D + F)$
2. $U = 1.2(D + F + T) + 1.6(L+H) + 0.5(L_r \text{ or } S \text{ or } R)$

3. $U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$
4. $U = 1.2D + 1.6W + 0.5L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $U = 1.2D + 1.0E_o + 0.5L + 0.2S$
6. $U = 0.9D + 1.6W + 1.6H$
7. $U = 0.9D + 1.0E_o + 1.6H$
8. 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 318-99 (ACI, 1999).

C. Load Combinations For Structures Combining Nominal Loads Using Allowable Stress Design (Steel)

All of the following combinations shall be satisfied for steel structures:

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. $S = 0.625(D + L + T + Eo)$
7. $S = 0.625(D + L + T + Wt)$
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 (AISC, 1989).

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	2.0
$D + H + W$	1.5	2.0
$D + H + E_s$	1.5	2.0
$D + H + W_t$	1.5	2.0

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 footings. In areas where the footings bear on in situ rock, the allowable bearing pressure is 7,000 lb/ft^2. In areas where the footings bear in existing or new fill areas, the allowable bearing pressure is 3,000 lb/ft^2. The allowable bearing pressure may be higher in areas where the fill material is entirely rock.

3.3.3 References

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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.

TABLES

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Table 3.3-1 Distances To Site Boundary and To Restricted Area Boundary and Wind Frequencies

Page 1 of 1

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

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FIGURES

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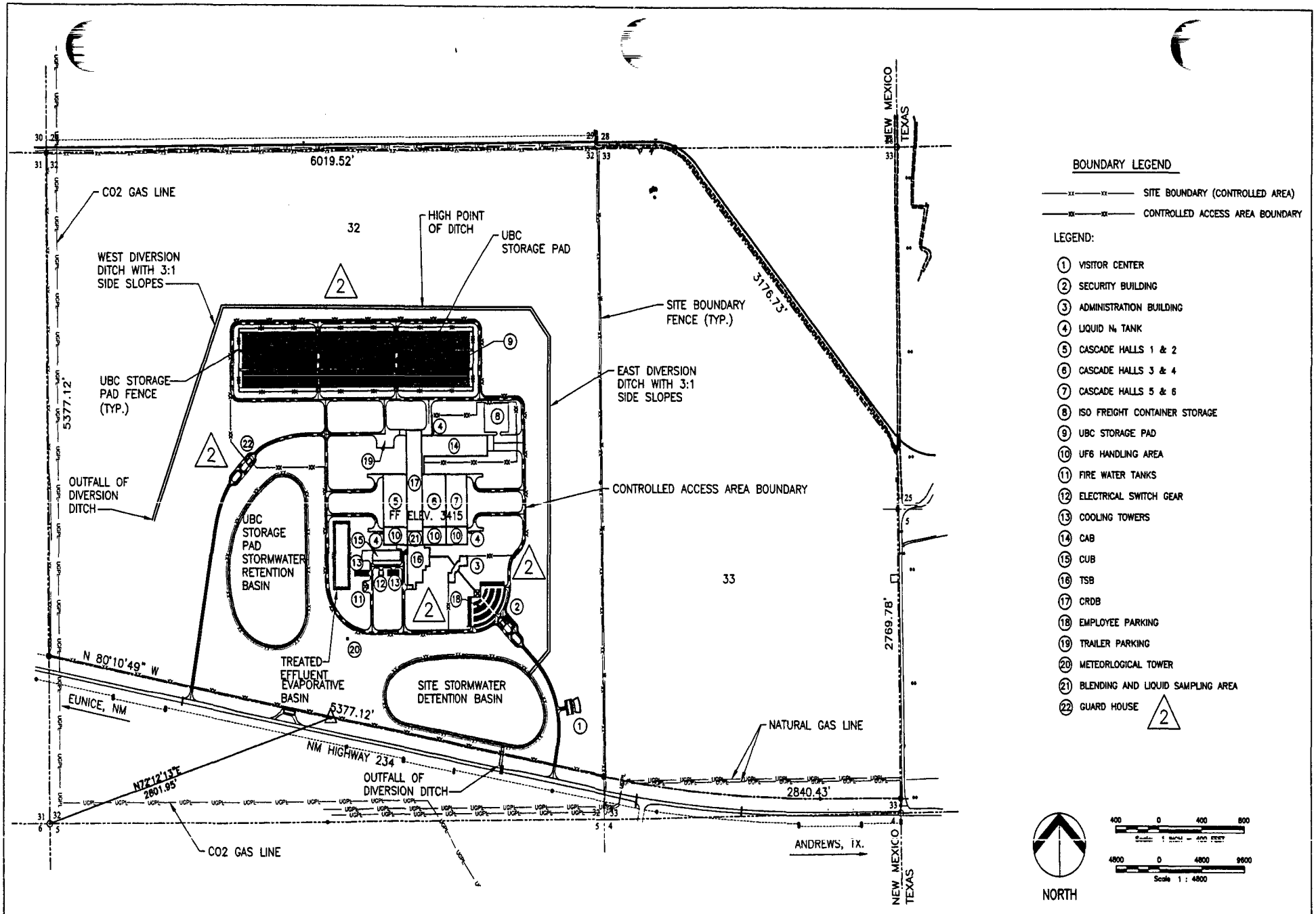

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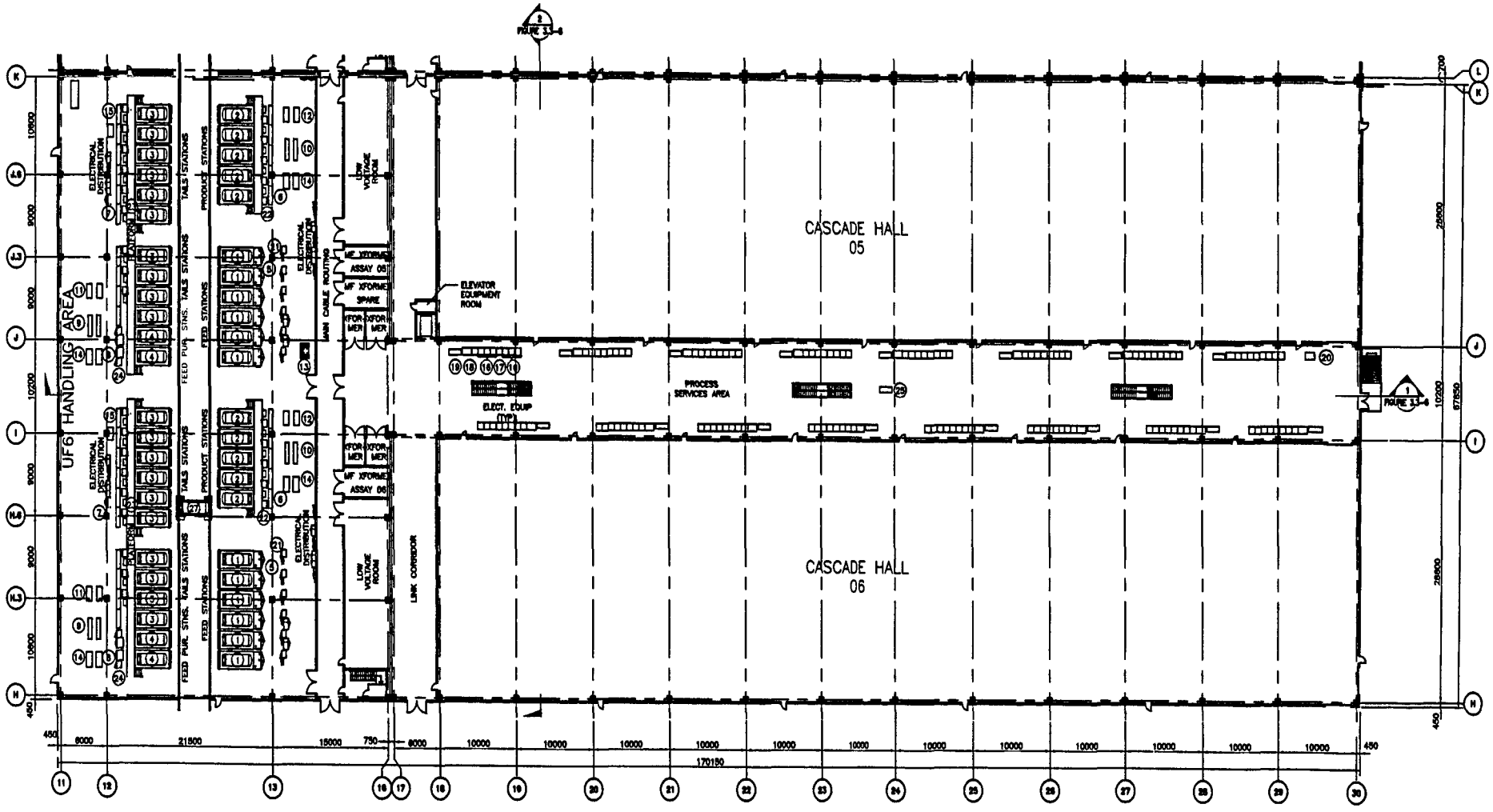
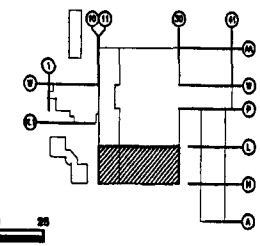
REFERENCE NUMBER
c0000001.dwg

FIGURE 3.3-1
FACILITY BUILDING AND AREAS

REVISION 2 DATE: JULY 2004





KEYPLAN

SCALE 1 : 250

EQUIPMENT LIST PER 1,000,000 SWU MODULE

1 SOLID FEED STATION
2 PRODUCT LOW TEMPERATURE TAKE-OFF STATION
3 TAILS LOW TEMPERATURE TAKE-OFF STATION
4 FEED PURIFICATION LOW TEMP. TAKE OFF STATION
5 FEED STATION HOTBOX
6 PRODUCT STATION VALVE FRAME
7 TAILS STATION VALVE FRAME
8 FEED PURIFICATION HOTBOX
9 FEED PURIFICATION COLD TRAP
10 PRODUCT VENT COLD TRAP
11 FEED PURIFICATION VACUUM PUMP/ TRAP SET
12 PRODUCT VACUUM PUMP/ TRAP SET
13 FOOT & HAND MONITOR
14 COLD TRAP HEAT/ CHILLER UNIT
15 TAILS VACUUM PUMP/ TRAP SET
16 MEDIUM FREQUENCY DISTRIBUTION CABINET
17 MAIN MEDIUM FR[illegible] DISTRIBUTION CABINET
18 RUN VARIABLE[illegible] DRIVE
19 CASCADE LO[illegible] ENTER
20 RUN UP VAR[illegible] Y DRIVE
21 FEED STATION LOCAL CONTROL CENTER
22 PRODUCT STATION LOCAL CONTROL CENTER
23 TAILS STATION LOCAL CONTROL CENTER
24 FEED PURIFICATION STATION LOCAL CONTROL CENTER
25 PROCESS SERVICES AREA LOCAL CONTROL CENTER
26 *
27 RAIL TRANSPORTER
28 CASCADE VALVE STATION
29 PRODUCT PUMPING TRAIN
30 TAILS PUMPING TRAIN
31 CONTINGENCY DUMP VACUUM PUMP/ TRAP SET
32 MOBILE CASCADE EVACUATION UNIT
33 MOBILE CASCADE SAMPLING UNIT
34 PRODUCT PUMP STARTER PANEL
35 TAILS PUMP STARTER PANEL
36 SODIUM FLUORIDE DUMP TRAPS
37 CASCADE COOLING WATER PUMPING UNIT
38 CCW LOCAL CONTROL PANEL
39 HVAC UNIT

NOTE: * ITEM NOT USED

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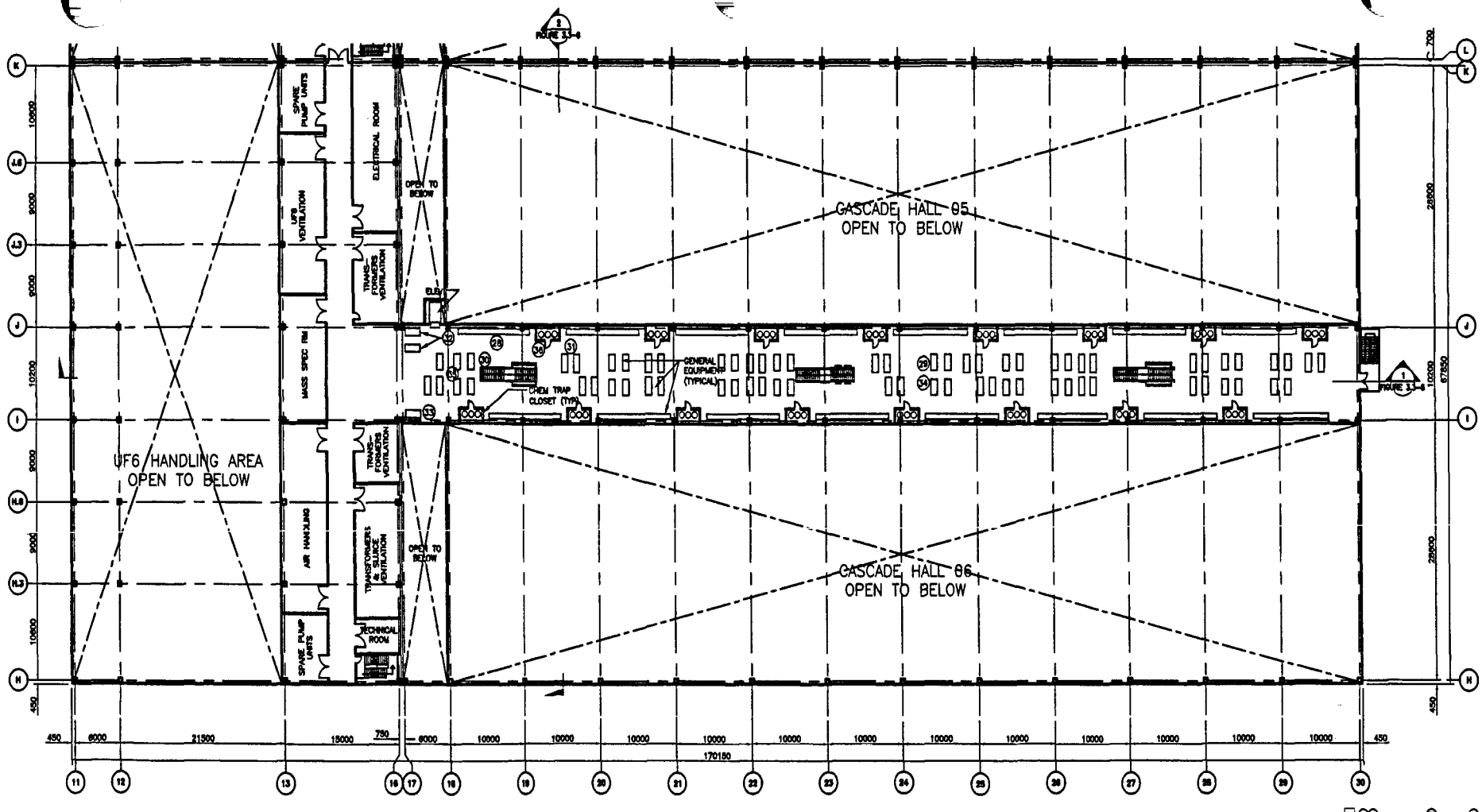
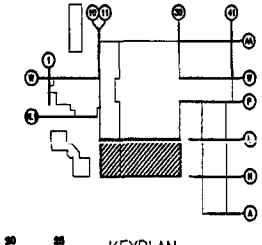
1000A2000

FIGURE 3.3-2
SEPARATIONS BUILDING MODULE
FIRST

REVISION DATE: [illegible]R 2003





KEYPLAN

SCALE 1 : 250

EQUIPMENT LIST PER 1,000,000 SWU MODULE

1 SOLID FEED STATION
2 PRODUCT LOW TEMPERATURE TAKE-OFF STATION
3 TAILS LOW TEMPERATURE TAKE-OFF STATION
4 FEED PURIFICATION LOW TEMP. TAKE OFF STATION
5 FEED STATION HOTBOX
6 PRODUCT STATION VALVE FRAME
7 TAILS STATION VALVE FRAME
8 FEED PURIFICATION HOTBOX
9 FEED PURIFICATION COLD TRAP
10 PRODUCT VENT COLD TRAP
11 FEED PURIFICATION VACUUM PUMP/ TRAP SET
12 PRODUCT VACUUM PUMP/ TRAP SET
13 FOOT & HAND MONITOR
14 COLD TRAP HEAT/ CHILLER UNIT
15 TAILS VACUUM PUMP/ TRAP SET
16 MEDIUM FREQUENCY DISTRIBUTION CABINET
17 MAIN MEDIUM FREQUENCY DISTRIBUTION CABINET
18 RUN VARIABLE FREQUENCY DRIVE
19 CASCADE LOCAL CONTROL CENTER
20 RUN UP VARIABLE FREQUENCY DRIVE
21 FEED STATION LOCAL CONTROL CENTER
22 PRODUCT STATION LOCAL CONTROL CENTER
23 TAILS STATION LOCAL CONTROL CENTER
24 FEED PURIFICATION STATION LOCAL CONTROL CENTER
25 PROCESS SERVICES AREA LOCAL CONTROL CENTER
26 *
27 RAIL TRANSPORTER
28 CASCADE VALVE STATION
29 PRODUCT PUMPING TRAIN
30 TAILS PUMPING TRAIN
31 CONTINGENCY DUMP VACUUM PUMP/ TRAP SET
32 MOBILE CASCADE EVACUATION UNIT
33 MOBILE CASCADE SAMPLING UNIT
34 PRODUCT PUMP STARTER PANEL
35 TAILS PUMP STARTER PANEL
36 SODIUM FLUORIDE DUMP TRAPS
37 CASCADE COOLING WATER PUMPING UNIT
38 CCW LOCAL CONTROL PANEL
39 HVAC UNIT

NOTE: * ITEM NOT USED

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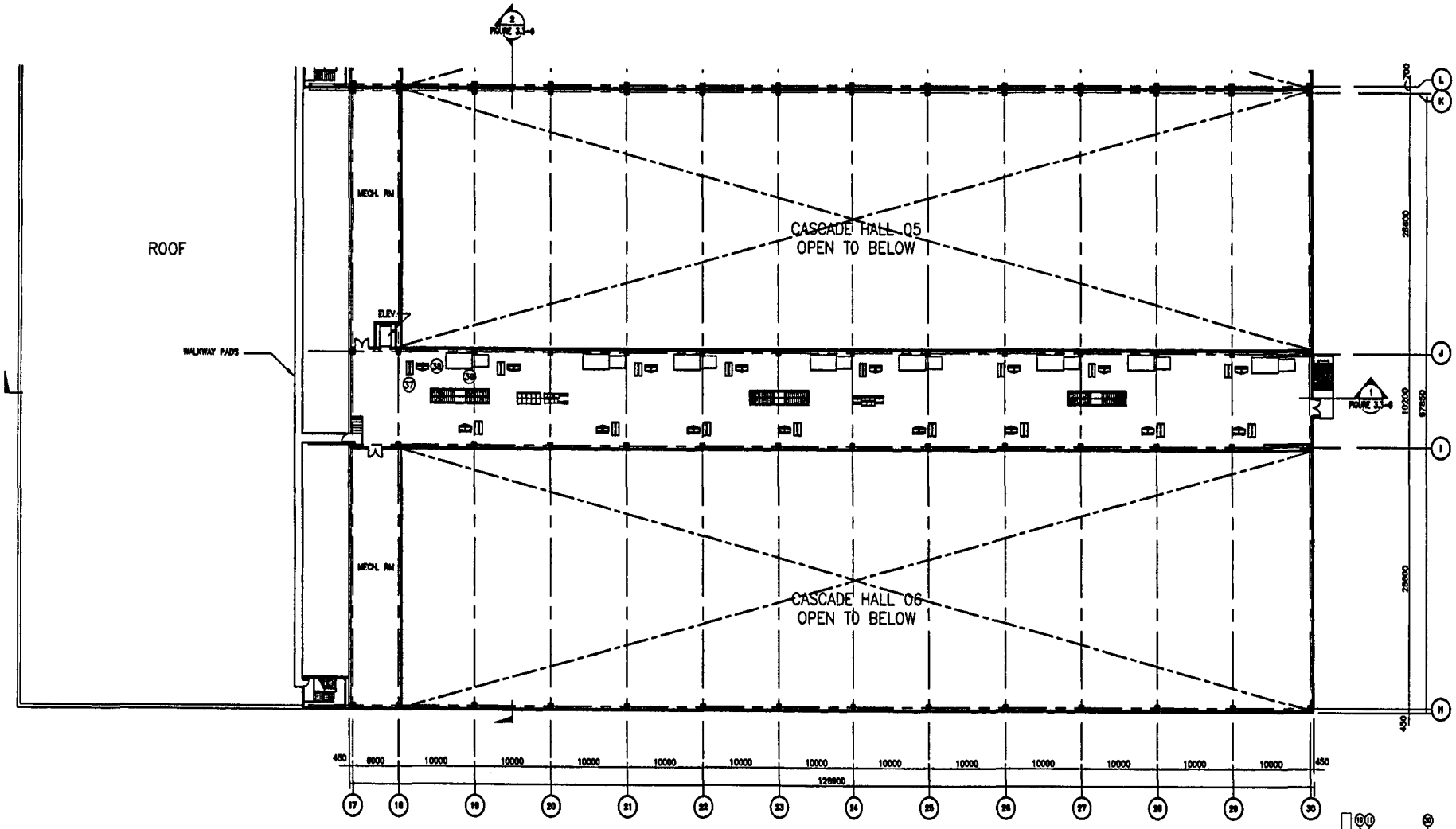
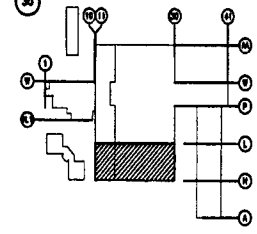
REFERENCE NUMBER
1000A2100

FIGURE 3.3-4
SEPARATIONS BUILDING MODULE
SECOND FLOOR

REVISION DATE: DECEMBER 2003





KEYPLAN

SCALE 1 : 250

EQUIPMENT LIST PER 1,000,000 SWU MODULE

1 SOLID FEED STATION
2 PRODUCT LOW TEMPERATURE TAKE-OFF STATION
3 TAILS LOW TEMPERATURE TAKE-OFF STATION
4 FEED PURIFICATION LOW TEMP. TAKE OFF STATION
5 FEED STATION HOTBOX
6 PRODUCT STATION VALVE FRAME
7 TAILS STATION VALVE FRAME
8 FEED PURIFICATION HOTBOX
9 FEED PURIFICATION COLD TRAP
10 PRODUCT VENT COLD TRAP
11 FEED PURIFICATION VACUUM PUMP/ TRAP SET
12 PRODUCT VACUUM PUMP/ TRAP SET
13 FOOT & HAND MONITOR
14 COLD TRAP HEAT/ CHILLER UNIT
15 TAILS VACUUM PUMP/ TRAP SET
16 MEDIUM FREQUENCY DISTRIBUTION CABINET
17 MAIN MEDIUM [illegible] DISTRIBUTION CABINET
18 RUN VARIAB[illegible] DRIVE
19 CASCADE L[illegible] CENTER
20 RUN UP VA[illegible]CY DRIVE
21 FEED STATION LOCAL CONTROL CENTER
22 PRODUCT STATION LOCAL CONTROL CENTER
23 TAILS STATION LOCAL CONTROL CENTER
24 FEED PURIFICATION STATION LOCAL CONTROL CENTER
25 PROCESS SERVICES AREA LOCAL CONTROL CENTER
26 *
27 RAIL TRANSPORTER
28 CASCADE VALVE STATION
29 PRODUCT PUMPING TRAIN
30 TAILS PUMPING TRAIN
31 CONTINGENCY DUMP VACUUM PUMP/ TRAP SET
32 MOBILE CASCADE EVACUATION UNIT
33 MOBILE CASCADE SAMPLING UNIT
34 PRODUCT PUMP STARTER PANEL
35 TAILS PUMP STARTER PANEL
36 SODIUM FLUORIDE DUMP TRAPS
37 CASCADE COOLING WATER PUMPING UNIT
38 CCW LOCAL CONTROL PANEL
39 HVAC UNIT

NOTE: * ITEM NOT USED

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1000A2200

FIGURE 3.3-5
SEPARATIONS BUILDING MODULE
THIRD [illegible]

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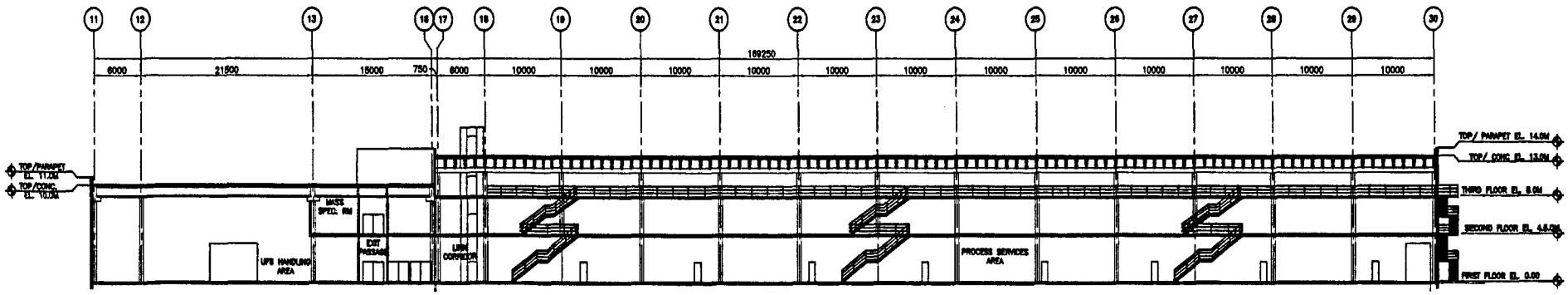

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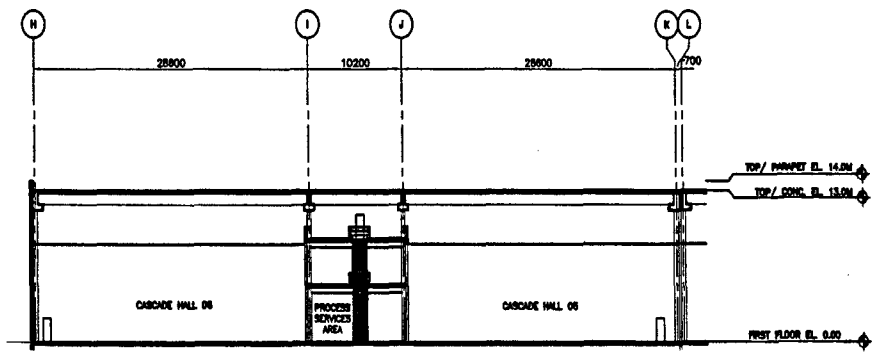

SECTION 2 FIGURE 3.3-6 — FIGURE 3.3-5, FIGURE 3.3-4, FIGURE 3.3-2

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FIGURE 3.3-6
SEPARATIONS BUILDING
MODULE SECTIONS

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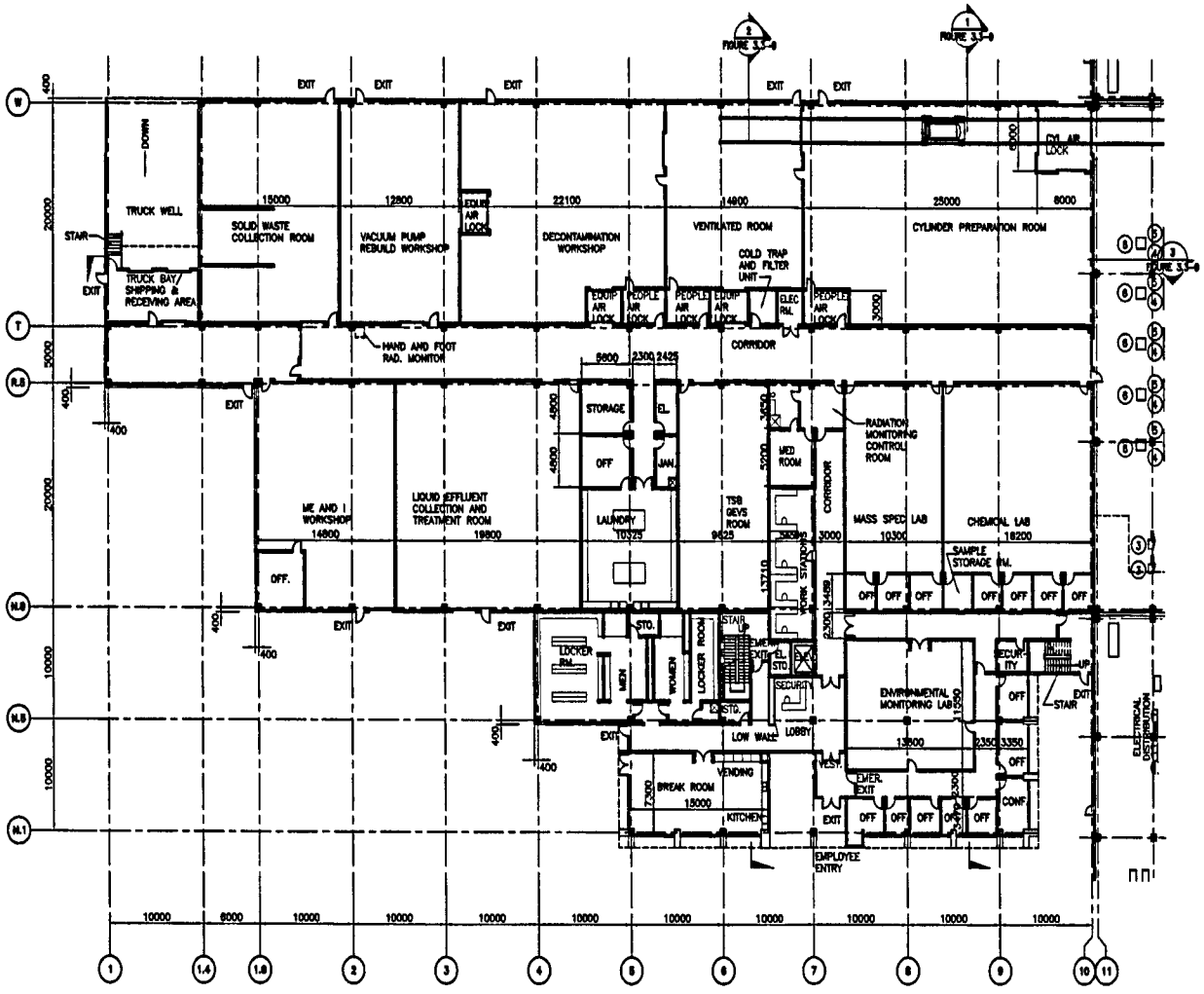

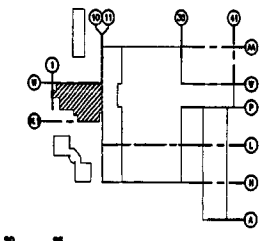

KEYPLAN

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FIGURE 3.3-7

TECHNICAL SERVICES BUILDING
FIRST

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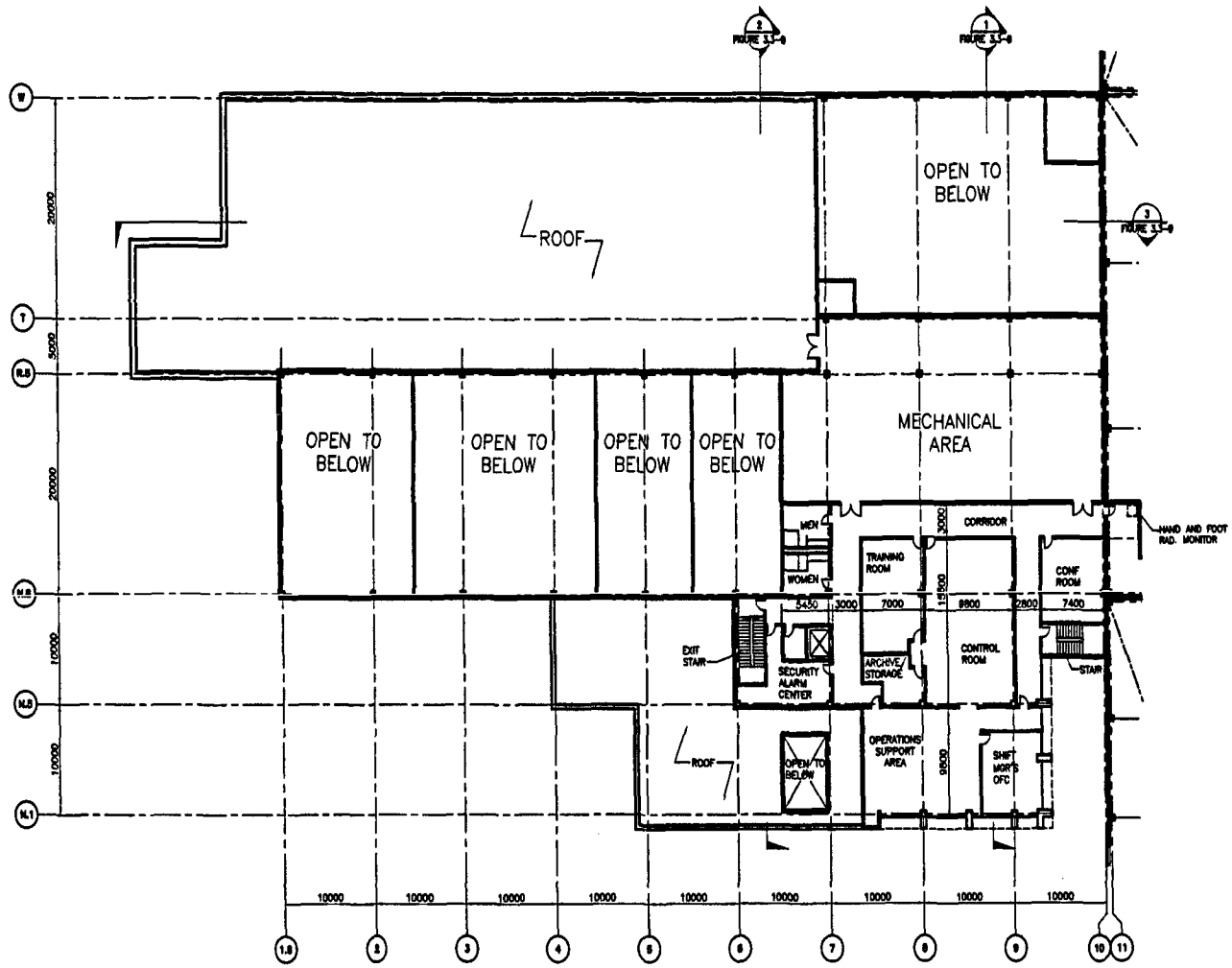

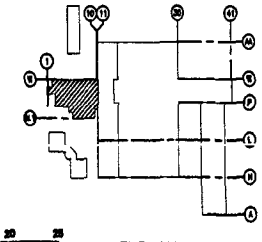

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FIGURE 3.3-8
TECHNICAL SERVICES BUILDING
SECOND FLOOR

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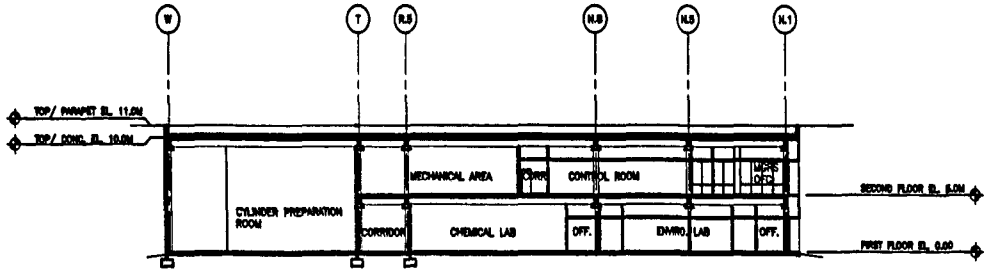

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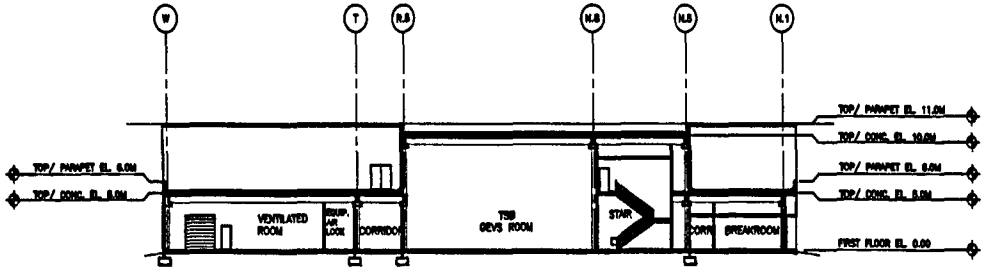
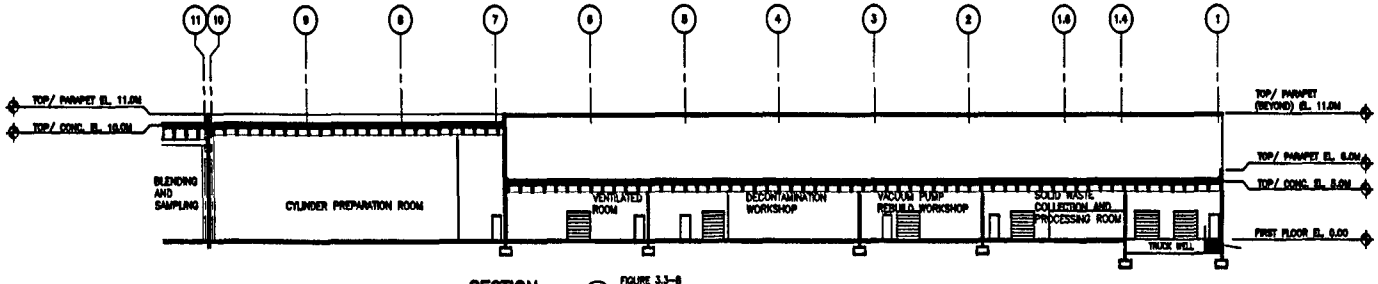


SECTION 2 FIGURE 3.3-8 FIGURE 3.3-7 FIGURE 3.3-9



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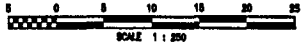

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FIGURE 3.3-9
TECHNICAL SERVICES BUILDING
SECTIONS

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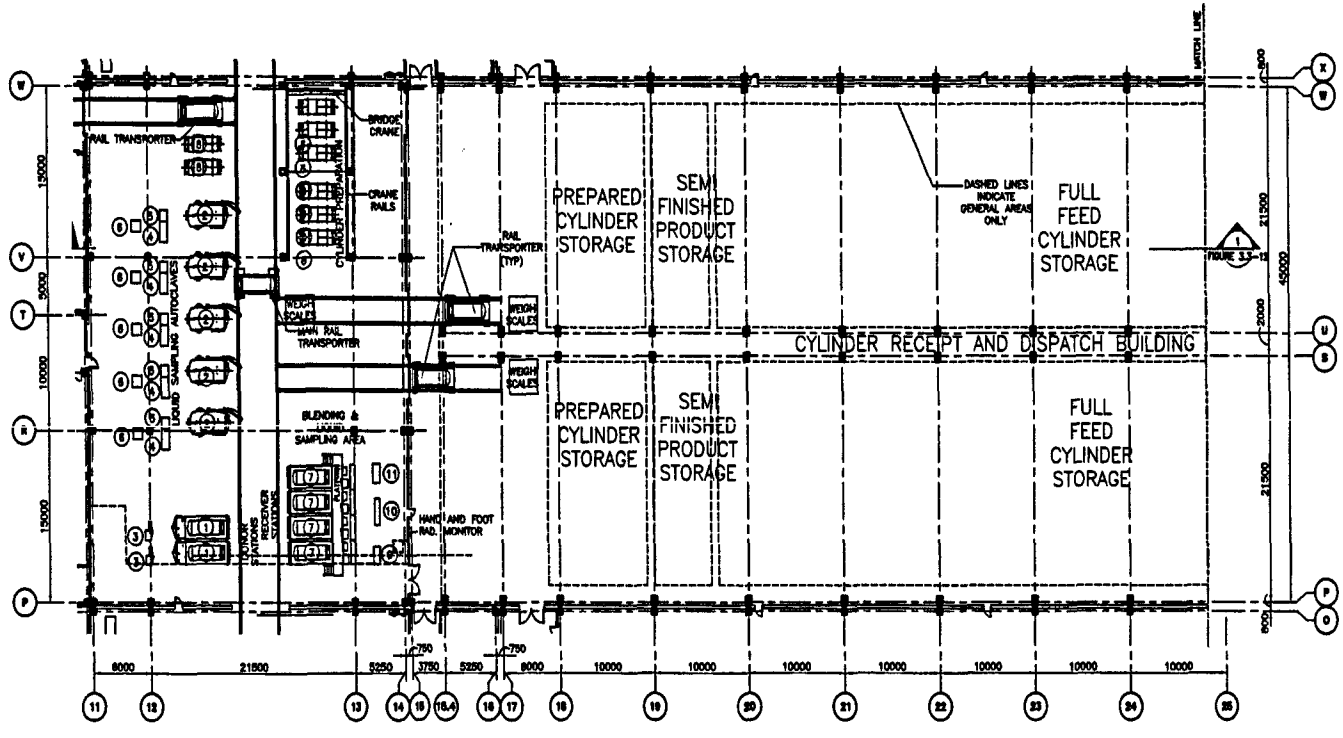

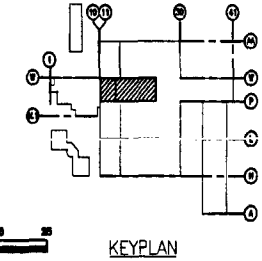

KEYPLAN

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EQUIPMENT LIST

1 PRODUCT BLENDING DONOR STATION
2 PRODUCT LIQUID SAMPLING AUTOCLAVE
3 DONOR STATION CONTROL CABINET
4 AUTOCLAVE CONTROL CABINET
5 AUTOCLAVE LOCAL CONTROL CENTER
6 HYDRAULIC POWER PACK
7 PRODUCT BLENDING RECEIVER STATIONS
8 48Y CYLINDERS
9 VACUUM PUMP / TRAP SET
10 UF_6 COLD TRAP
11 COLD TRAP HEAT / CHILLER UNIT

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1100A2000a

FIGURE 3.3-10
CYLINDER RECEIPT AND DISPATCH BUILDING FIRST FLOOR PART A
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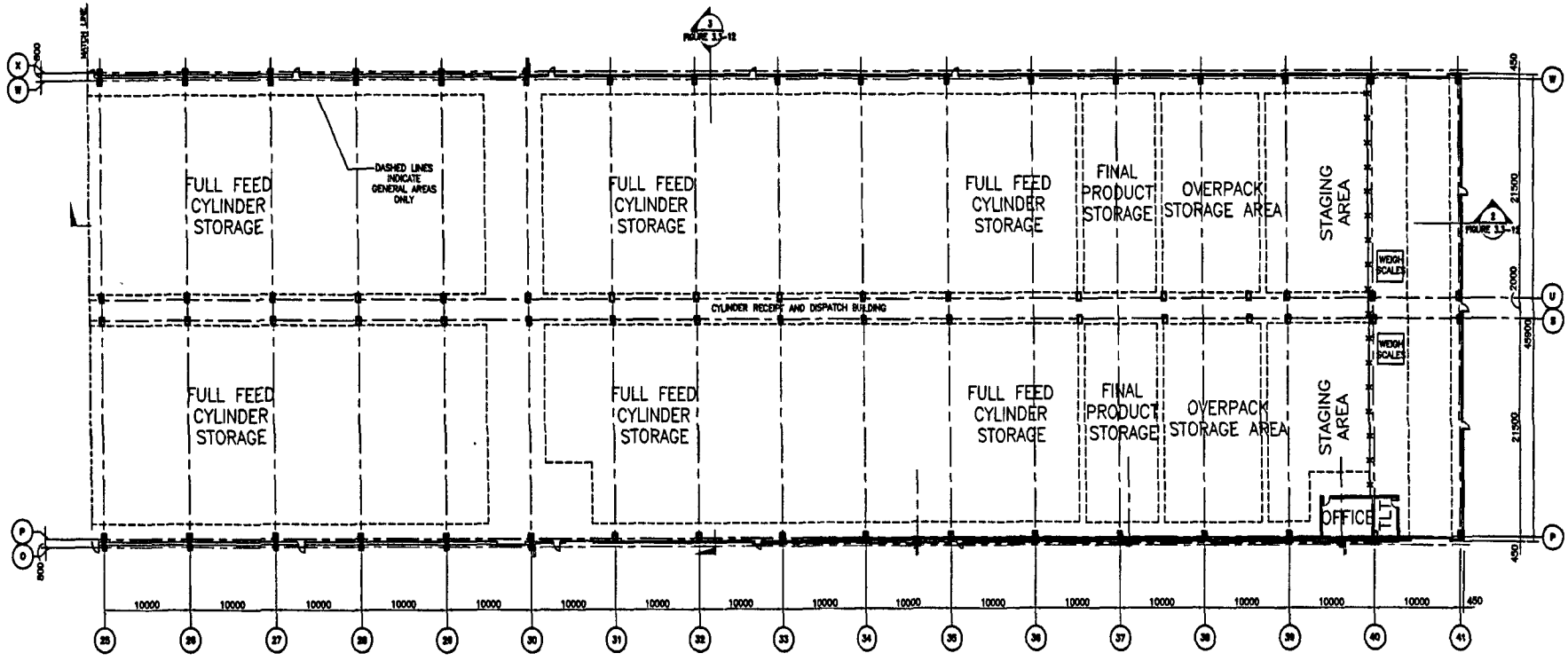

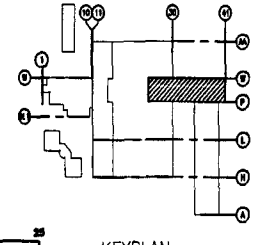

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1100A2000b

FIGURE 3.3-11

CYLINDER RECEIPT[illegible] DISPATCH BUILDING [illegible] OR PA[illegible]

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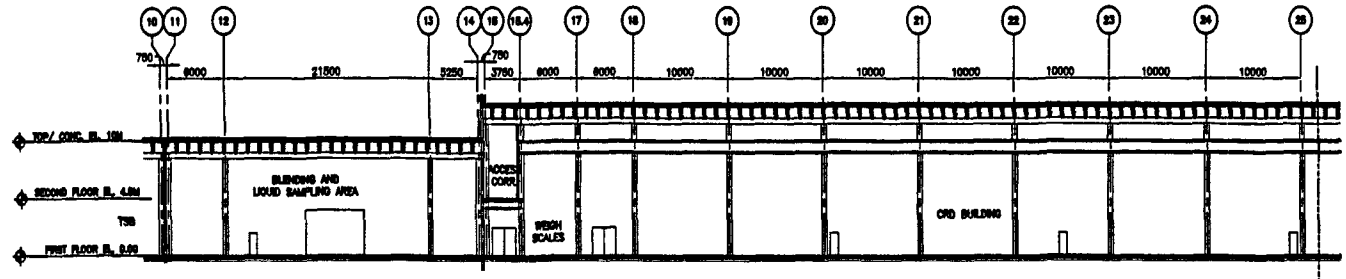

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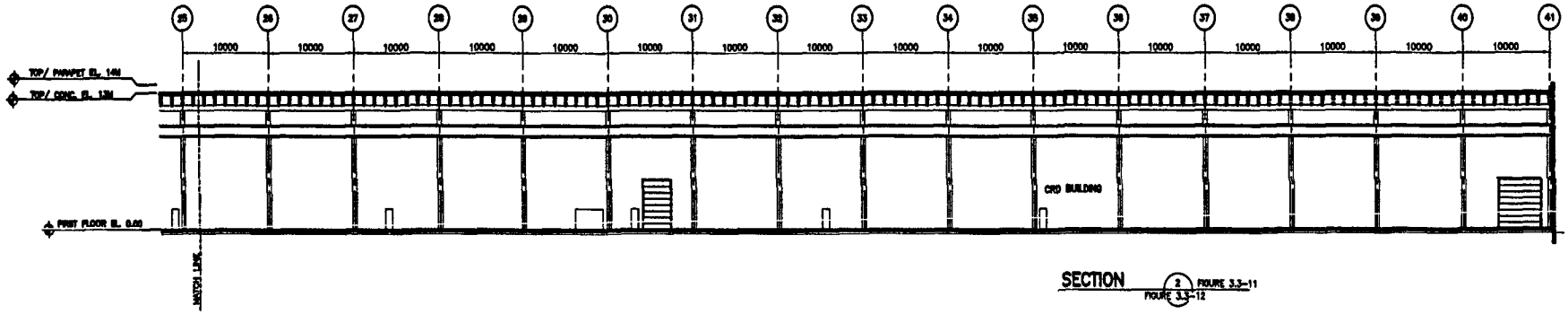
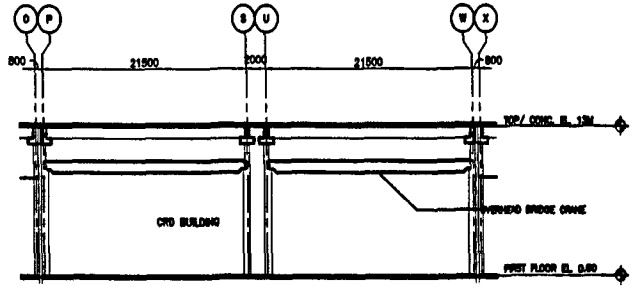


SECTION 2 FIGURE 3.3-11 FIGURE 3.3-12



SECTION 3 FIGURE 3.3-11 FIGURE 3.3-12

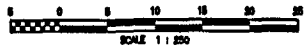


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FIGURE 3.3-12

CYLINDER RECEIPT AND DISPATCH BUILDING SECTIONS

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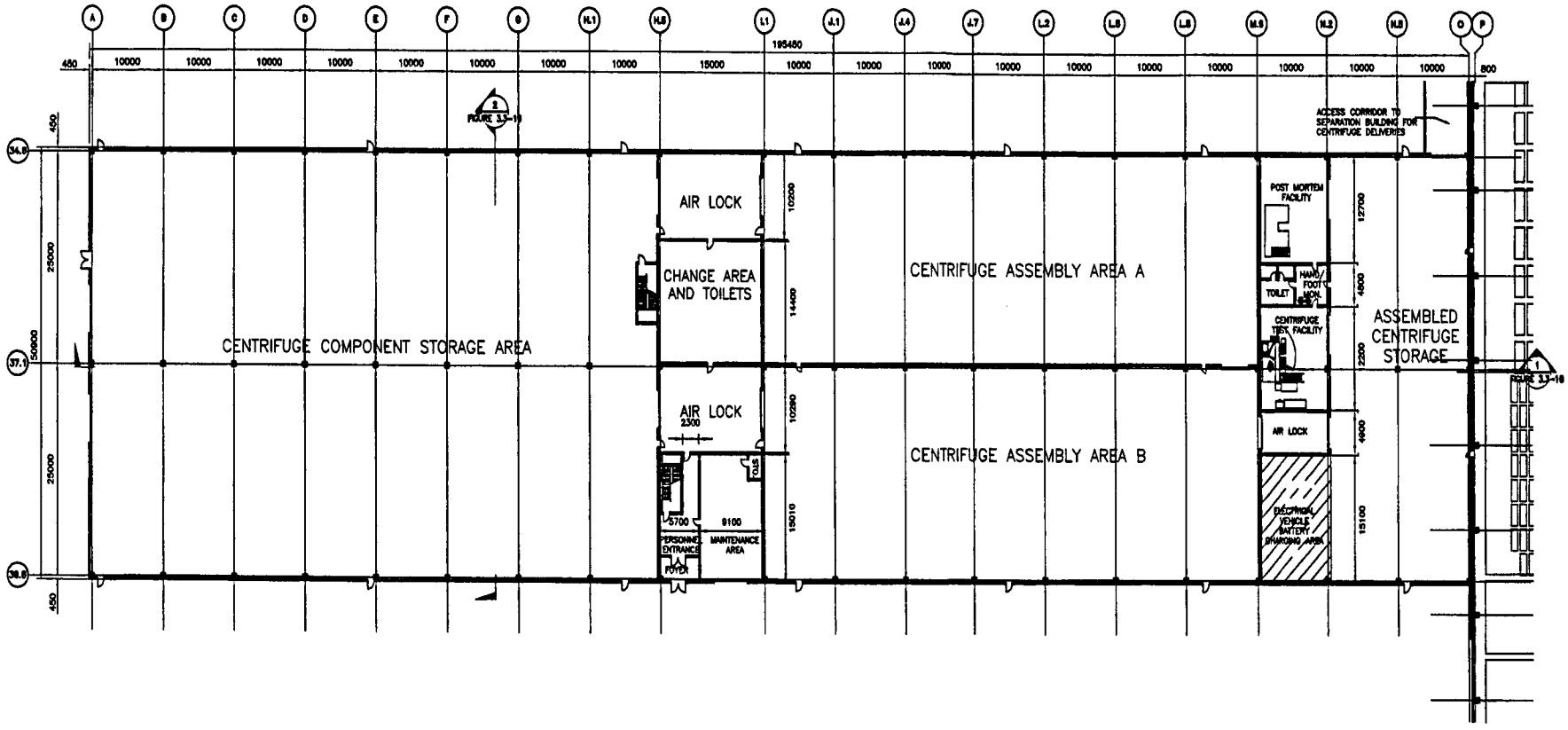

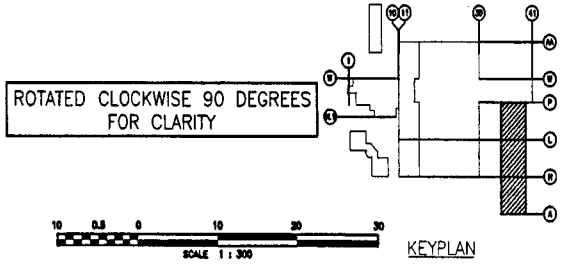

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FIGURE 3.3-13
CENTRIFUGE ASS[illegible]Y BUILDING
FIRS[illegible]

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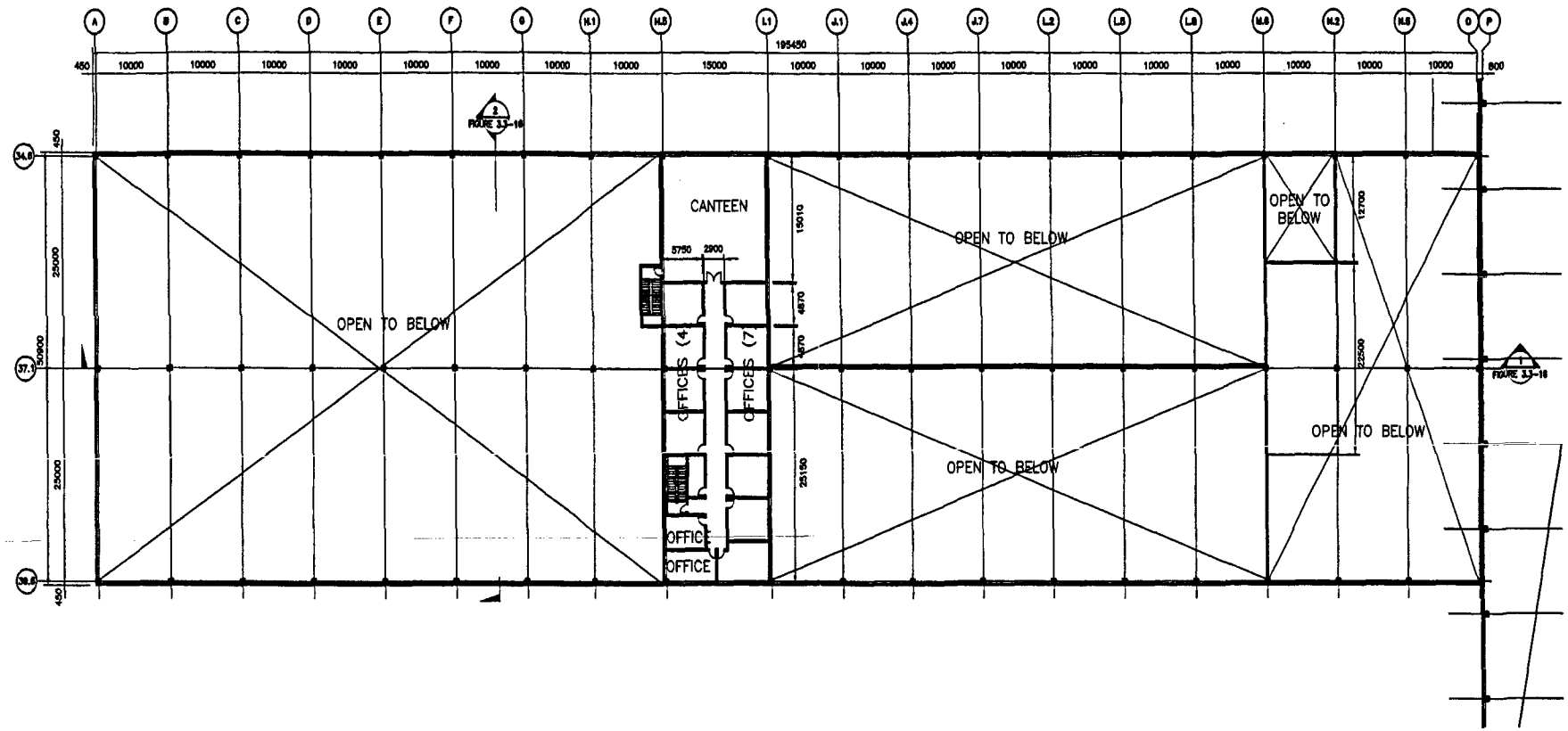

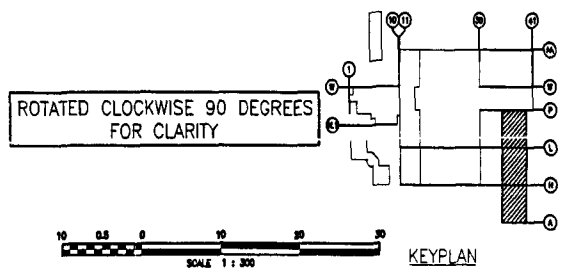

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1300A2100

FIGURE 3.3-14

CENTRIFUGE ASSEMBLY BUILDING
SECOND FLOOR

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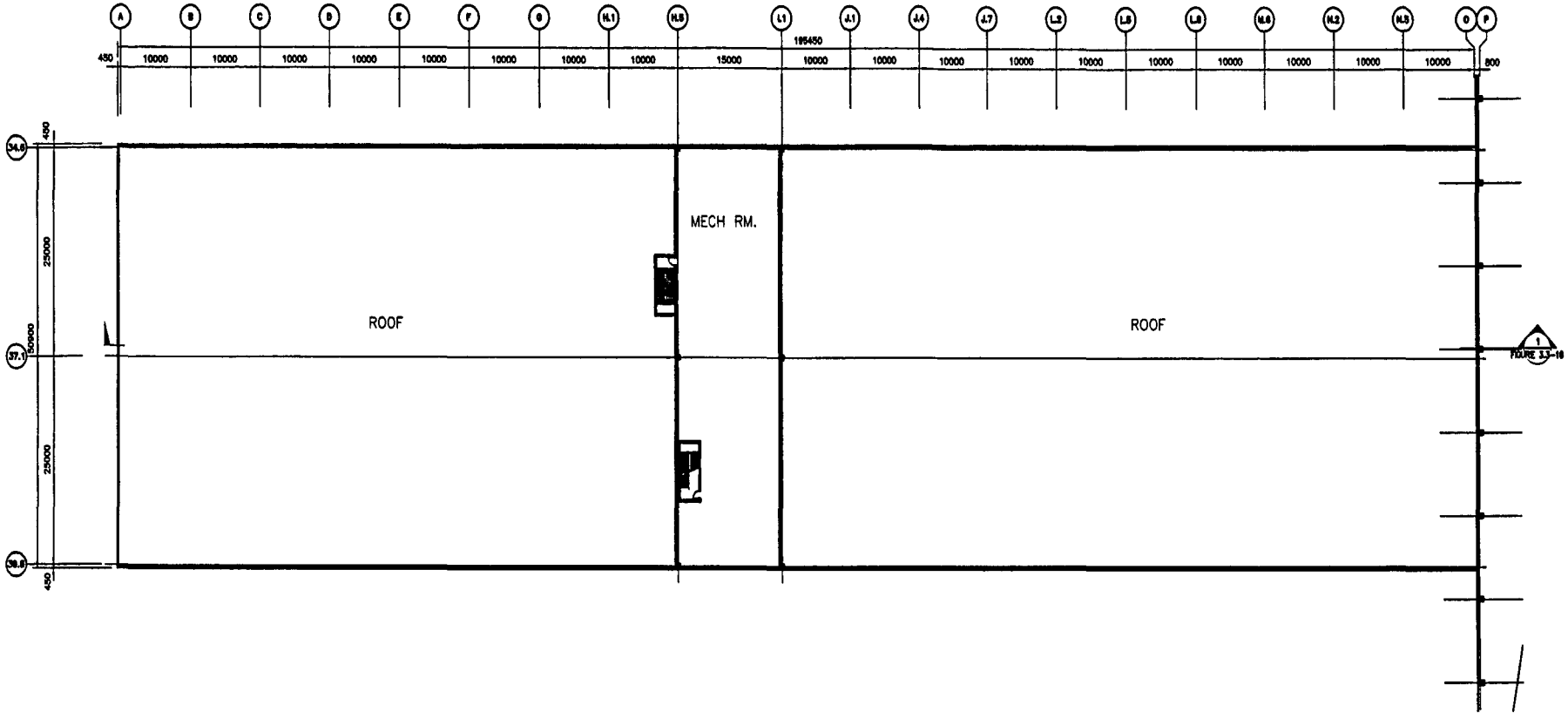

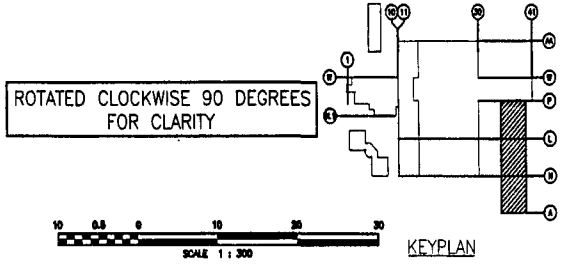

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REFERENCE NUMBER
1300A2200

FIGURE 3.3-15

CENTRIFUGE ASS[illegible] BUILDING
PEN[illegible]

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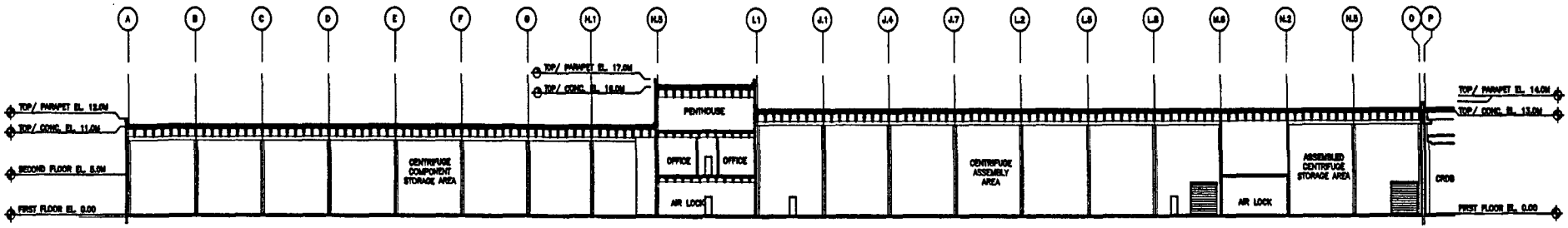

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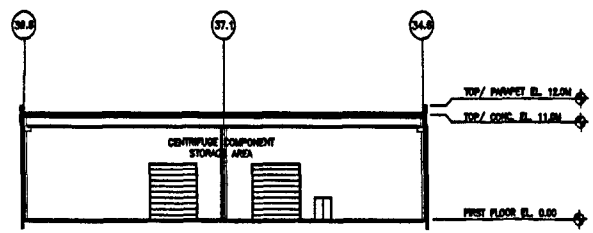
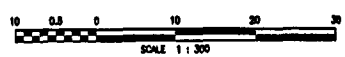


SECTION 2 FIGURE 3.3-14 FIGURE 3.3-13 FIGURE 3.3-16



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REFERENCE NUMBER
1300A4000

FIGURE 3.3-16

CENTRIFUGE ASSEMBLY BUILDING SECTIONS

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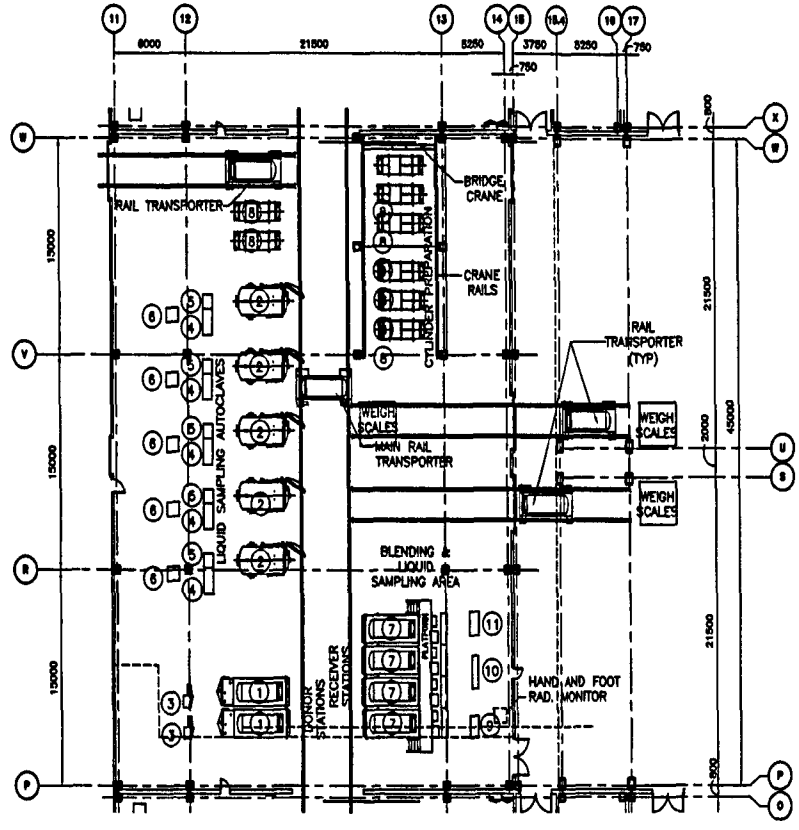

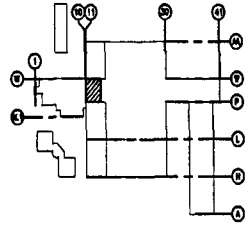

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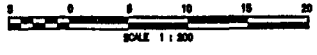

EQUIPMENT LIST

1 PRODUCT BLENDING DONOR STATION
2 PRODUCT LIQUID SAMPLING AUTOCLAVE
3 DONOR STATION CONTROL CABINET
4 AUTOCLAVE CONTROL CABINET
5 AUTOCLAVE LOCAL CONTROL CENTER
6 HYDRAULIC POWER PACK
7 PRODUCT BLENDING RECEIVER STATIONS
8 48Y CYLINDERS
9 VACUUM PUMP [illegible] SET
10 UF_6 COLD TRA[illegible]
11 COLD TRAP [illegible] UNIT

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1200A2000

FIGURE 3.3-17
BLENDING AND LIQU[illegible] SAMPLING AREA
FIRST [illegible]

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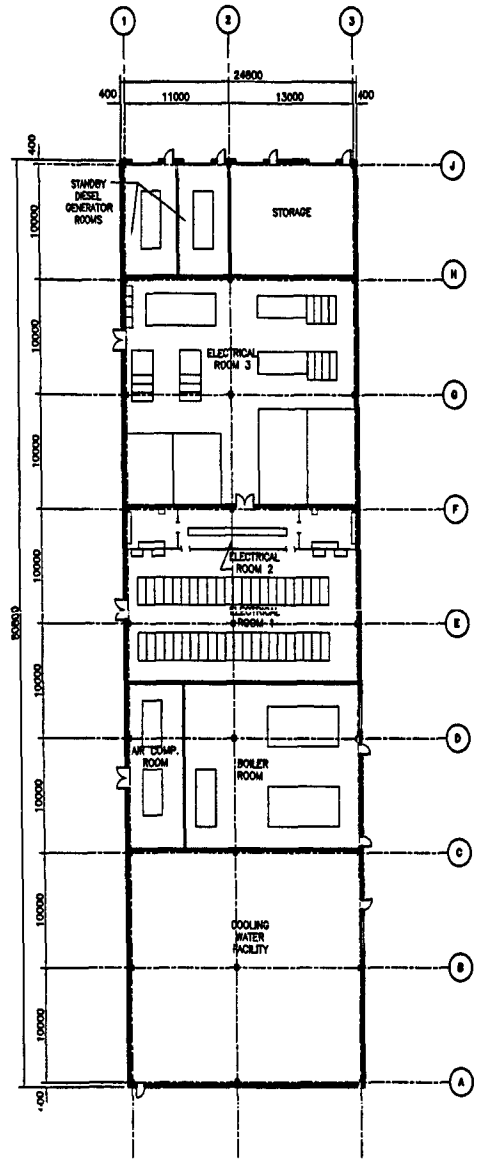

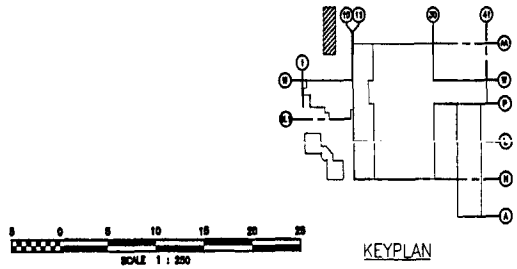

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FIGURE 3.3-18
CENTRAL UTILITIES BUILDING

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Figure 3.4-18 P&ID Gaseous Effluent Vent System Technical Services Building
Sheet 2 of 2
Figure 3.4-19 Process Flow Diagram Centrifuge Test and Post Mortem Facilities Exhaust Filtration System
Figure 3.4-20 Rail Transporter Equipment Drawing

3.4 PROCESS DESCRIPTIONS

This section provides a description of the enrichment processes and systems analyzed as part of the integrated safety assessment. A brief overview of the entire enrichment process is provided followed by a detailed description of each process system. The 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).

The enrichment systems are comprised of the following four major systems:

- UF_6 Feed System
- Cascade System
- Product Take-off System
- Tails Take-off System.

The above systems are used only for the enrichment process. In addition to the four primary systems listed above, there are several major support systems 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:

- Gaseous Effluent Vent Systems (GEVSs)
- 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.

The enrichment process at the NEF is basically the same process described in the Safety Analysis Report for the Claiborne Enrichment Center (LES, 1993). The Nuclear Regulatory Commission (NRC) documented its review of the Claiborne Enrichment Center license application and concluded that Louisiana Energy Services' (LES) application provided an adequate basis for safety review of facility operations and that construction and operation of the Claiborne Enrichment Center would not pose an undue risk to public health and safety (NRC, 1994). The design of the NEF incorporates the latest design and safety features from the Urenco enrichment facilities currently operating in Europe.

The major process design differences between the Claiborne Enrichment Center and the NEF are summarized below. Additional details are provided at the beginning of each subsection on how NEF compares to the Claiborne Enrichment Center processes and systems.

The primary difference between the Claiborne Enrichment Center and the NEF is the increase in enrichment capacity. The NEF is designed for 3.0 million separative work units (SWU) per year. The Claiborne Enrichment Center was designed for 1.5 million SWU per year.

The Claiborne Enrichment Center used a feed system that operated above atmospheric pressure. During purification or when feeding to the centrifuges, the UF_6 in the cylinders was in a liquid phase. Autoclaves were used to heat the feed cylinders and to contain any UF_6 in the event there were any leaks in the feed cylinder or piping. The feed purification station used chilled water at 3.9°C (39.0°F) supplied from a common system to chill the purification cylinder.

The NEF feed and feed purification systems do not use UF_6 in the liquid phase. Also, the operating pressure in the feed and purification systems stays considerably below atmospheric pressure. The UF_6 feed is changed from the solid phase to the gaseous phase without going through the liquid phase. This is achieved because the feed system temperature is maintained below the triple point. The Solid Feed Stations used in the UF_6 Feed System are not constructed as autoclaves. There is no need for secondary confinement barriers due to the UF_6 not being in the liquid phase and the subatmospheric pressure of the system. The Feed Purification Low Temperature Take-off Station is cooled by air that is chilled by individual electrically operated chiller units (not water). The purification stations operate at –25°C (-13°F), which is considerably colder than the Claiborne Enrichment Center design. Not using liquid UF_6 and operating at a subatmospheric pressure are major safety enhancements from the Claiborne Enrichment Center design.

The Claiborne Enrichment Center used cooled air at 10°C (50°F) to chill the product cylinders while they were in the Product Take-off Stations. For the NEF, the Product Take-off Stations are cooled by air that is chilled by individual electrically operated chiller units. The Low Temperature Take-off Stations operate at –25°C (-13°F), which is considerably colder than the previous design. The operating pressure for the Low Temperature Take-off Stations is considerably lower for the NEF.

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.

Figure 3.4-1, Pictorial Representation of the Enrichment Process, illustrates the process flow in schematic form. An overview 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

The first step in the process is the receipt of the feed cylinders and preparation to feed the UF_6 through 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 (ANSI, applicable version), 48Y or 48X 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. The maximum feed flow rate is 187 kg/hr (412 lb/hr) based on a maximum capacity of 545,000 SWU/yr per Cascade Hall.

To begin the enrichment process, a 48-in feed cylinder is placed into a Solid Feed Station. There are six Solid Feed Stations per Cascade Hall. 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 (subatmospheric), the solid UF_6 sublimes into a gas. An important safety feature of the feed system is that at no time does the UF_6 go into a liquid phase.

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. These stations consist of insulated enclosures that are maintained at –25°C (-13°F) by electrically operated chiller units. 48X or 48Y cylinders are placed into the Low Temperature Take-off Station and chilled to –25°C (-13°F). As the gaseous UF_6 enters the cylinder, desublimation into solid UF_6 occurs. In addition to the Low Temperature Take-off Station, 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 Gaseous Effluent Vent System. 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. The pressure in the main header 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

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 the enriched UF_6 stream. The tails stream is UF_6 that has been depleted of ^{235}U isotope.

3.4.1.3 Product Take-off System

The function of the Product Take-off System is to provide continuous withdrawal of the enriched gaseous UF_6 product from the cascades. The maximum product flow rate per Cascade Hall is 18.4 kg/hr (40.6 lb/hr) based on a maximum Cascade Hall capacity of 545,000 SWU/yr.

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 Low Temperature Take-off Stations per Cascade Hall. Normally two are on-line when using 30B cylinders. Each Low Temperature Take-off Station consists of an insulated enclosure that is maintained at –25°C (-13°F) by electrically operated chiller units. A 30B or a 48Y cylinder is placed into the Low Temperature Take-off Station and cooled to –25°C (-13°F). The 30B cylinders contain final product to be shipped to the customer. The 48Y 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.

The entire system operates at subatmospheric 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 a carbon trap, an aluminum oxide trap, and a vacuum pump. The carbon trap removes small traces of UF_6 and the aluminum oxide trap removes any HF from the gas flow.

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

The primary function of the Tails Take-off System is to provide continuous withdrawal of the gaseous UF_6 tails from the cascades. The maximum tails flow rate is 168 kg/hr (370 lb/hr) based on a maximum Cascade Hall capacity of 545,000 SWU/yr. 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 via a primary header, goes through a pumping train, and then to Tails Low Temperature Take-off Stations. There are ten Low Temperature Take-off Stations per Cascade Hall. Under normal operation, seven of the Low Temperature Take-off Stations are in operation receiving tails and three are 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 Low Temperature Take-off Stations and cooled to –25°C (-13°F). As the gaseous depleted UF_6 (tails) enters the cylinder, it desublimes into solid UF_6.

The entire system operates at subatmospheric 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

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 system can also be used to transfer product from a 30B or 48Y cylinder to another 30B cylinder without blending.

The Product Blending System is sized for the complete 3,000,000 SWU/year 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 Low Temperature Take-off Stations 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 or 48Y product cylinders at various enrichment levels are placed into the Blending Donor Stations and are heated to sublime the solid UF_6 to gas. The sublimed gas from the two Blending Donor Stations is transported to four Blending Receiver Stations. Each Blending Receiver Station consists of an insulated enclosure that is maintained at –25°C (-13°F) by electrically operated chiller units. Empty 30B cylinders are placed into the station and cooled to –25°C (-13°F). As the gaseous UF_6 from the Blending Donor Stations enters the cylinder, desublimation into solid UF_6 occurs.

There are no vacuum pumps used to transfer product in this system. The system has a vent system similar to the product vent system.

3.4.1.6 Product Liquid Sampling System

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.

This is the only system in the NEF that changes 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) with three sample bottles, is connected to the cylinder valve. After closing the autoclave door, the autoclave is heated to 70°C (158°F) via 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 reaches approximately +2.5 bar (36.3 psia), 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 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.

3.4.2 UF_6 Feed System

The NEF UF_6 Feed System uses a process similar to the original LES Claiborne Enrichment Center. The primary differences are as follows:

A. Feed Station Operating Conditions.

The Claiborne Enrichment Center used a feed station that operated above atmospheric pressure. UF_6 in the feed cylinder was maintained in the liquid phase. Normal UF_6 pressure in the feed cylinder was above atmospheric, at 1.8 bar (26.1 psia). Normal station heating temperature was up to 110°C (230°F). The Claiborne Enrichment Center used a sealed autoclave for secondary containment of the feed cylinder to prevent exposure in the event a leak developed in the primary containment (cylinder and piping).

The NEF sublimes solid UF_6 directly to gaseous UF_6 at subatmospheric pressure, without entering the liquid phase. Normal feed cylinder pressure is 500 mbar (7.25 psia) and the station temperature during heating is limited to 61°C (142°F). As a result, a Solid Feed Station is used to heat the feed cylinder rather than an autoclave.

B. Feed Purification Low Temperature Take-off Cylinder Operating Temperature.

The Claiborne Enrichment Center cylinder temperature was maintained at +3.9°C (39°F) by spraying the cylinder with chilled water. The NEF chills the cylinder to -25°C (-13°F) by using cold air from a refrigeration unit.

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. 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 hydrogen fluoride (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 is shown in Figure 3.4-2, Process Flow Diagram, UF_6 Feed System.

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 Separations Building Gaseous Effluent Vent System (GEVS) 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 Technical Services Building (TSB) and reused.

The UF_6 Feed Systems are located in the UF_6 Handling Area of each Separations Building Module. The location of the major equipment is shown on Figure 3.3-2, Separations Building Module, First Floor and Figure 3.3-3, UF_6 Handling Area, Equipment Location. 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 components of the UF_6 Feed System are described below.

A. Solid Feed Station.

A Solid Feed Station consists of an insulated box with a non-flammable core, complete with rails for the electric carriage of the cylinder transporter. A Solid Feed Station is shown in Figure 3.4-3, Solid Feed Station Equipment Drawing. Each Solid Feed Station incorporates an electric air heater and circulation fan, with controls, to provide thermal energy to the solid UF_6 to cause it to sublime within the cylinder. A weighing device is provided in the Solid Feed Station (a frame with four load cells) to provide 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 an opening at the back. 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, 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 components of the Feed Purification Subsystem are described below:

1. Low Temperature Take-off Station (LTTS). A LTTS consists of a composite panel box construction complete with rails for the electric carriage of the cylinder transporter. An LTTS is shown in Figure 3.4-4, Low Temperature Take-off Station Equipment Drawing. The box 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 has a defrost cycle, using a heater, to prevent ice buildup on the coils. A hot air blower directed at the cylinder valve prevents UF_6 from desubliming and blocking the cylinder inlet. A weighing device is provided in the LTTS (a frame with four load cells and associated instrumentation) to provide 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. A rubber bellows is fitted around the back opening, which envelops the cylinder valve, to prevent cooled air from leaking out of the LTTS. Similar seals on the other 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 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. Each UF_6 cold trap consists of an insulated horizontal tube with internal baffles. A UF_6 cold trap is shown in Figure 3.4-5, UF_6 Cold Trap Equipment Drawing. 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 approximately 70 L (19 gal) of silicon oil, as the heat exchange media, which circulates around each cold trap. These Feed Purification Subsystem heater/chiller units are separated by over 30 m (100 ft) from other heat/chiller units in similar subsystems. 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. The UF_6 cold traps are followed by vacuum pump/chemical trap sets. Each set has a carbon trap, an aluminum oxide trap, an insulated vacuum pump with nitrogen purge, and an oil trap on either side of the vacuum pump. A chemical trap is shown in Figure 3.4-6, Chemical Trap Equipment Drawing. The vacuum pump exhausts into the Separations Building GEVS. The activated carbon trap removes small traces of UF_6. The aluminum oxide trap removes HF. Oil traps are installed before and after the vacuum pump to prevent oil migration both upstream and into the Separations Building GEVS.

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.

Each UF_6 Feed System is dedicated to an individual Cascade Hall of eight cascades. Gaseous UF_6 feed (natural, 0.711 $^{w}/_{o}$ ^{235}U) flows from the Solid Feed Stations to the centrifuge cascades. The system is designed to provide a total maximum Cascade Hall flow rate of 187 kg/h (412 lb/hr) based on a capacity of 545,000 SWU/ year. A single cascade in operation generates a minimum flow rate of 13.5 kg/h (29.75 lb/hr). The peak flow rate for an individual cascade during the feed inlet sequence is 27 kg/h (59.5 lb/hr).

The entire UF_6 Feed System operates at subatmospheric 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 six 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. Two Solid Feed Stations are in either standby mode or preparation mode. The sixth Solid Feed Station is a spare and 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 using distinguishing markings/identification of 48X and 48Y cylinders within the UF_6 area to ensure cylinders containing product are not placed on-line to the cascade and 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 Separations Building 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 subatmospheric pressures and to provide the required flow rate. UF_6 piping and valve stations where UF_6 desublimation could occur are heated. The building heating and ventilation 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. 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 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 Separations Building GEVS is provided any time a UF_6 line is disconnected.

E. Before discharge to the Separations Building 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 fully fluorinated synthetic oil such as "Fomblin," a perfluorinated polyether (PFPE).

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, 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 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 with an incorrect cylinder type loaded. 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. A Cascade Hall's normal maximum capacity is based on 545,000 SWU/yr.

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 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 sensors are duplicated and others are installed in triplicate. Action is initiated if any one out of two or three sensors reach alarm levels.

A. Solid Feed Station

Both the Solid Feed Station air temperature and cylinder temperature are monitored to prevent over pressurization of the feed cylinder 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 53°C (127°F). The first alarm level is 62°C (144°F) for the Solid Feed Station air and 54°C (129°F) for the cylinder to give the operator warning of high temperature. The second alarm level is 55°C (131°F) for the cylinder, which 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. One is failsafe hard wired and measures cylinder temperature, and the other is a failsafe capillary type and measures the Solid Feed Station air temperature. These provide extra safety margin to prevent overheating the cylinder if the air temperature control fails. Both systems automatically de-energize the air heater and blower, if either the cylinder temperature reaches 55°C (131°F) or the Solid Feed Station air temperature reaches 63°C (145°F).

The feed cylinder pressure is monitored with dual sensors to prevent over pressurization of the cylinder, piping and valves. Normal pressure is 500 mbar (7.25 psia). The first alarm level is 600 mbar (8.7 psia) to give the operator warning of over pressure. The second alarm level at 850 mbar (12.3 psia) 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. The first weight trip of 800 kg (1,764 lb) gross is used to indicate a cylinder is present in the Solid Feed Station. The 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, it is used to modulate the Solid Feed Station feed control valve. Normal pressure is approximately 55 mbar (22.1 in. H_2O). A first alarm, at 58 mbar (23.3 in. H_2O), warns the operator of high pressure. The second alarm level, at 64 mbar (25.7 in. H_2O), automatically switches the Solid Feed Station to standby and closes the outlet valve.

Low feed pressure is also alarmed. The first alarm, at 50 mbar (20.1 in. H_2O), warns the operator of loss of feed supply. A second alarm at 30 mbar (12.0 in. H_2O) indicates that 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 the instruments is used to modulate the Solid Feed Station feed control valve. Normal pressure is 55 mbar (22.1 in. H_2O). A first alarm at 57 mbar (22.9 in. H_2O) warns the operator of high pressure. The second alarm level, at 67 mbar (26.9 in. H_2O), automatically switches all of the Solid Feed Stations to standby and closes each Solid Feed Station's outlet valve. A low alarm at 20 mbar (8.03 in. H_2O) warns 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 first high alarm at 57 mbar (22.9 in. H_2O) warns the operator of high pressure. The second high alarm level, at 70 mbar (28.1 in. H_2O), automatically prevents feeding into the cascades. A first low alarm at 50 mbar (20.1 in. H_2O) warns of loss of the feed supply. The second low alarm level, at 20 mbar (8.03 in. H_2O), 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 approximately 50 mbar (20.1 in. H_2O). A first alarm warns of high pressure at 400 mbar (5.8 psia). At 450 mbar (6.53 psia) the LTTS Valve Hotbox inlet valve is closed and the LTTS is tripped to standby. At a pressure below 40 mbar (16.1 in. H_2O) the cylinder is available for feed purification, and below 10 mbar (4.01 in. H_2O) 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. Similar trips and alarms are established for a 48X type cylinder. 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 to a normal value of –25°C (-13°F). In addition to controlling the LTTS temperature, one output is monitored by the Plant Control System (PCS) and warns when the air temperature rises from –25°C (-13°F) to –5°C (23°F). 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 measures the circulating air temperature and is fail-safe hardwired. The second measures the air inside the LTTS and is a fail-safe capillary device. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above set points. Set point on the hardwired instrument is 50°C (122°F) and set point on the capillary instrument is 63°C (145°F). If heater trip occurs from these two instruments, the LTTS is automatically taken off-line and put into a standby mode.

To prevent desublimation in the cylinder valve, hot air is blown over the valve with a hot air blower. A temperature sensor on the valve controls the temperature to 63°C (145°F).

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.

During the purification operation, the UF_6 cold trap outlet pressure is monitored. A first high alarm, at 70 mbar (28.1 in. H_2O), warns of high pressure in the UF_6 cold trap. A first low alarm, at 20 mbar (8.03 in. H_2O), 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 purification cylinder. A second low alarm,

at 1 mbar (0.2 in. H_2O), closes the UF_6 cold trap outlet valve to prevent UF_6 flow to the vacuum pump. A second high alarm, at 80 mbar (32.1 in. H_2O), trips the UF_6 cold trap off-line, switching the heater/chiller unit off and closing the inlet and outlet valves.

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 at 3 mbar (1.2 in. H_2O).

A weighing system monitors the contents of the UF_6 cold trap. A first alarm at 40 kg (88.2 lb) warns that the UF_6 cold trap is approaching capacity. At 50 kg (110 lb) the UF_6 cold trap inlet and outlet valves are closed.

The temperature of the UF_6 cold trap is controlled 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 (gasback). A low alarm at –63°C (-81°F) warns of a chiller unit fault. A first high alarm at –52°C (-62°F) closes the UF_6 cold trap outlet valve and a second high alarm at 25°C (77°F) warns of high temperature during gasback. At 30°C (86°F) the unit trips off-line to avoid desublimation of UF_6 in the header.

F. Feed Purification Vacuum Pump/Chemical Trap Sets

To prevent the carbon trap from overheating and overfilling with UF_6, there are two instruments. One sensor monitors the carbon trap temperature. This sensor will close the Feed Purification UF_6 cold trap outlet valves when carbon trap temperature exceeds 42°C (108°F). This blocks flow to the vacuum pump/chemical trap set. The carbon trap also has a weigh system. In addition to local weight display, this system will shut down the vacuum pump when the high weight set point is reached. The carbon trap weigh system has an alarm at 6 kg (13.2 lb) to warn the operators the carbon trap is approaching full. The vacuum pump trip occurs at 12 kg (26.5 lb).

The activated aluminum oxide (Al_2O_3) trap on the vacuum pump/chemical trap set is also 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 weigh indicator.

Increase in weight is used to monitor accumulation of UF_6 in the carbon trap and HF in the aluminum oxide trap. The chemical traps are replaced based on the accumulated weight.

3.4.3 Cascade System

The primary difference between the Louisiana Energy Services, Claiborne Enrichment Center, and the NEF is the increase from seven to eight cascades per Cascade Hall. The Cascade System used in the NEF is virtually the same as the Claiborne Enrichment Center Cascade System. The NRC staff previously reviewed the Claiborne Enrichment Center SAR license application relative to the Cascade System and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Cascade System is provided in NUREG-1491 (NRC, 1994), Section 3.4.

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 the ^{235}U isotope content in one, the "product," and decreasing the ^{235}U content in the other, the "tails." 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. The enrichment process is illustrated in Figure 3.4-7, The Enrichment Process, and Figure 3.4-8, Cascade Process Scherne Equipment Drawing.

3.4.3.2 Major Components

The major components of the Cascade System are:

A. Centrifuges

The latest qualified centrifuge, Model TC-12, contains a rotor that is used to produce the centrifugal force needed for isotope separation. An electromagnetic motor drives the rotor. A stationary center post in the rotor provides for 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. A gas centrifuge is shown in Figure 3.4-9, Principle of a Gas Centrifuge.

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 Pipe-work

The arrays of centrifuges that make up a cascade are grouped into blocks; the cascade pipe-work connects these blocks and provide for 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 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 Evacuation Rigs and Sampling Rig

Two Mobile Evacuation Rigs are used to sustain a low pressure in the cascade prior to and during centrifuge run-up or run-down. A Mobile Sample Rig is provided to periodically collect

UF_6 samples from a cascade. The rigs connect to a cascade at the cascade valve station. A rig consists of a liquid nitrogen dewar, a roots vacuum pump, an activated carbon trap, and a rotary vane vacuum pump preceded by an aluminum oxide trap and followed by an oil trap. The sample rig has, in addition, product and tails sample bottles. Rig exhausts are connected to the Separations Building GEVS.

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. The carbon trap of the mobile cascade sample rig has a weighing system that will automatically trip the associated vacuum pump on high carbon trap weight. 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 subatmospheric 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 process 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 Cascade System for each Cascade Hall is capable of producing a maximum of 545,000 SWU/year. The nominal capacity of each Cascade Hall is 500,000 SWU/yr. It is limited to a maximum final product assay of 5.0 $^{w}/_{o}$ ^{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 level, the process operator has the ability to manipulate the process to restore it to normal. At the second and sometimes the third alarm level, 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 assessed assuming 6 $^{w}/_{o}$ ^{235}U enrichment. 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 H/U ratio that is near optimum. Therefore, the possibility of a criticality incident in a centrifuge cascade can be considered not credible.

3.4.3.8.2 UF_6 Product Pipework

Product pipework in the Separations Building varies in size up to a maximum nominal diameter of 150 mm (5.9 in). Only minimal surface deposition of UF_6 occurs in pipework but criticality safety has been assessed for the possibility of localized blockages in pipes with the formation of uranyl fluoride due to air inleakage.

MONK8A (SA, 2001) calculations have been performed for generic arrays of pipe intersections, filled entirely with uranyl fluoride / water mixture at optimum moderation at 6.0 $^{w}/_{o}$ enrichment. The minimum permitted free space between intersections was determined to be 520 mm (20.5 in) for 150 mm (5.9 in) nominal pipe, and 135 mm (5.3 in) for 100 mm (3.9 in) nominal pipe; no spacing restriction applies to pipework of nominal diameter 65 mm (2.6 in).

The above restrictions apply to individual pipe runs with up to 64 intersections or adjacent pipe runs totaling up to 64 intersections.

Parallel pipe runs containing product material will either fit within the criticality safe value for cylinder diameter or be explicitly modeled.

The Separations Building pipework conforms to the above specifications. If not, explicit calculations will be performed. For example, the spacing restriction might not be satisfied, but the pipework might have fewer than 64 intersections.

3.4.4 Product Take-off System

The NEF Product Take-off System uses a process similar to the original Louisiana Energy Services Claiborne Enrichment Center, however there are differences. The NRC staff previously reviewed the Claiborne Enrichment Center license application relative to the Product Take-off System and concluded that the description, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Product Take-off System is provided in NUREG-1491 (NRC, 1994), Section 3.5. The primary differences are:

Product Take-off Cylinder Operating Temperature

The Claiborne Enrichment Center cylinder temperature was maintained at +10°C (50°F). Cool air from a central system was used to maintain the temperature. The NEF chills cylinders to –25°C (-13°F) by using cold air from refrigeration units mounted on each LTTS.

System Pressure (at the product cylinder)

The Claiborne Enrichment Center used a relatively high pressure of 430 mbar (6.24 psia) in the header at the cylinder. The high pressure was generated via two pump sets. The first pump set was in the "primary" header from each cascade and consisted of two pumps – a first stage and a second stage - that were in series. There were seven cascades; therefore, there were 14 pumps total in the seven sets. After these seven pump sets, the discharges all combined into a single "secondary" header. In this secondary header, there were two high-pressure vacuum pumps. These two pumps were in parallel.

The pressure (vacuum) at the cylinder for the NEF is substantially lower. It has been reduced to no greater than 80 mbar (32.1 in. H_2O). This lower vacuum level is possible primarily because the cylinder is chilled to –25°C (-13°F). The product pumping system for the NEF combines the product from eight cascades into a main header and uses two vacuum pumps in series for each Cascade Hall. There is a spare set of vacuum pumps for each Cascade Hall. These are in parallel arrangement. The lower operating vacuum level eliminates the need for a high-pressure pump in the system.

Product Header Heat Tracing

The operating pressure in the Claiborne Enrichment Center header following the high-pressure vacuum pumps required heat tracing and valve hot boxes to prevent desublimation at the building temperatures. For the lower pressure in the NEF system, the building ambient temperature is sufficient to prevent desublimation and heat tracing is not necessary.

Product Vent Subsystem

The current system has two parallel UF_6 cold trap and vacuum pump/chemical trap sets for each Cascade Hall. The Claiborne Enrichment Center used three UF_6 cold traps and vacuum pump/chemical trap sets for each Separations Building Module, with a common spare shared between the two Cascade Halls.

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. The product is transported via a train of vacuum pumps to chilled 30 or 48-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. The system is shown in Figure 3.4-10, Process Flow Diagram Product Take-off System.

Under normal operating conditions, the 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 Separations Building 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 TSB and reused.

The Product Take-off System is located in the UF_6 Handling Area and the Process Services Area of the Separations Building. The major equipment locations are shown on Figure 3.3-2, Separations Building Module, First Floor; Figure 3.3-3, UF_6 Handling Area Equipment Location; and Figure 3.3-4, Separations Building Module, Second Floor. It is operated from the Control Room, with the exception of vacuum pump and cylinder maintenance and preparation operations, which are controlled locally.

3.4.4.2 Major Components

The major components of the Product Take-off System are listed below.

A. Product System Main Header

The product 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 two product pumping trains connected in parallel. One pump train is 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. A rubber bellows is fitted around the back opening, which

envelops the cylinder valve, to prevent cooled air from leaking out of the Product LTTS. A hot air blower is used to keep the valve and its surrounding area 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.

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 any 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, an aluminum oxide trap, and an insulated vacuum pump with internal nitrogen purge and oil traps on either side. The exhaust from the pump goes to the Separations Building GEVS.

The activated carbon trap removes small traces of UF_6. The aluminum oxide trap removes HF. The oil traps are installed before the pump to prevent back diffusion and after the pump to prevent oil from being transferred into the Separations Building GEVS.

E. Assay Sampling System

Piping installed on the product header after the product pumping trains allows a product assay sample to be collected in a sample bottle. The sample system is comprised of automatic and manual valves, nitrogen purging, and an evacuation pump/chemical trap set similar to the one described above. However, this set does not contain an aluminum oxide trap for HF removal.

F. On-line Mass Spectrometer System

A piping connection on the product header, after the product pumping trains, allows a small gas sample to be fed to an on-line mass spectrometer. The analysis results allow any required adjustments to the cascades.

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 of eight cascades. The system is designed to continuously remove the enriched UF_6 product from the cascades under all operating conditions. The maximum product flow rate of 18.4 kg (40.6 lb) per hour is based on a maximum capacity of 545,000 SWU per year (produced by each Cascade Hall).

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 Low Temperature Take-off Stations for each Cascade Hall. Of these five, two are on-line during normal operation. These two Product LTTSs are adequate to handle product flow when 30-in cylinders are being used. 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. Separations Building 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

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 Product Take-off System operate at subatmospheric 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 Separations Building GEVS remove any releases from the work area.

D. Before discharge to the Separations Building 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 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, preventing cylinder removal.

H. Hydrocarbon lubricants are not used in any pumps. All pumps are lubricated with fully fluorinated synthetic oil such as "Fomblin," a perfluorinated polyether (PFPE).

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 48 in cylinders 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. A Cascade Hall's normal maximum capacity is based on 545,000 SWU per year.

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. 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, 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. Normal operating pressure is less than 2 mbar (0.803 in H_2O). The first alarm level, high (H) is set to give operator warning of high pressure. A second alarm level, high high (HH) 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 less than 2 mbar (0.803 in H_2O). The first alarm level (H) warns the operator of high pressure. The second alarm level (HH) 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 less than 55 mbar (22.1 in H_2O). The first alarm level, set at 70 mbar (28.1 in H_2O), provides the operator warning of high pressure. A second alarm level at 80 mbar (32.1 in H_2O) 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 less than 50 mbar (20.1 in H_2O). The first alarm level is set at 50 mbar (20.1 in H_2O) to automatically initiate the timed cylinder venting sequence. A second alarm level set at 70 mbar (28.1 in H_2O) warns

of high pressure. A third alarm level, at 80 mbar (32.1 in H_2O), 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 to a normal value of –25°C (-13°F). In addition to controlling the Product LTTS temperature, one output is monitored by the Plant Control System and warns when the air temperature rises to from -25°C (-13°F) to –5°C (23°F). 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 measures the circulating air temperature and is fail-safe hardwired. The second measures the air inside the Product LTTS and is a fail-safe capillary device. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above set points. Set point on the hardwired instrument is 50°C (122°F) and set point on the capillary instrument is 53°C (127°F). If heater trip occurs from these two instruments, the Product LTTS is automatically taken off-line and put into a standby mode.

To prevent desublimation in the cylinder valve, heated air is blown over the valve with a hot air blower. A temperature sensor on the valve controls the temperature to 63°C (145°F).

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 level at 90 mbar (26.1 in. H_2O) warns of high pressure. A second alarm level at 99 mbar (39.7 in. H_2O) closes the Product LTTS vent valve to prevent flow back into the Product Take-off System.

During the venting operation, the product vent UF_6 cold trap outlet pressure is monitored. A first low alarm level at 20 mbar (8.03 in. H_2O) indicates the UF_6 cold trap is empty in gas back mode. A second low alarm level, at 1 mbar (0.401 in. H_2O), closes the UF_6 cold trap outlet valve automatically to prevent UF_6 flow to the vacuum pump. A first high alarm level at 70 mbar (28.1 in. H_2O) warns of high pressure. A second high alarm level,

at 80 mbar (32.1 in. H_2O), 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 at 3 mbar (1.2 in. H_2O).

A weighing system monitors the contents of the UF_6 cold trap. A first alarm at 20 kg (44.1 lb) warns that the UF_6 cold trap is approaching capacity. At 25 kg (55.1 lb) the UF_6 cold trap inlet and outlet valves are closed and the UF_6 cold trap is switched off-line.

The temperature of the UF_6 cold trap is controlled at –60°C (-76°F) during cooling to desublime any UF_6 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 at –63°C (-81.4°F) warns of a chiller unit fault. A first high alarm at –52°C (-61.6°F) closes the UF_6 cold trap outlet valve and a second high alarm at 25°C (77°F) warns of high temperature during gasback. At 30°C (85°F) the unit trips off-line to avoid desublimation of UF_6 in the header.

2. Vacuum Pump/Chemical Trap Sets.

To prevent the carbon trap from overheating and overfilling with product, there are two instruments. One sensor monitors the chemical trap temperature. This sensor will close the product vent UF_6 cold trap outlet valve when carbon trap temperature exceeds 42°C (108°F). This blocks flow to the vacuum pump/chemical trap set. This sensor will also provide an automatic trip of the associated vacuum pump on carbon trip high temperature. The carbon trap also has a weigh system. In addition to local weight display, this system will shut down the vacuum pump when the high weight set point is reached.

The activated aluminum oxide (Al_2O_3) trap on the vacuum pump/chemical trap set is also 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 used to monitor accumulation of UF_6 in the carbon trap and HF in the aluminum oxide trap. 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 at 70 mbar (28.1 in. H_2O) 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 48Y or 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 48Y or 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.

Calculations were performed on infinite two-dimensional arrays of full 48Y or 30B product cylinders. Inside each cylinder a region of UO_2F_2/water mixture was located. The remainder of the interior of the cylinder was assumed to be filled with 6.0 $^w/_o$ ^{235}U enriched UF_6. Cylinders in the arrays were placed with the valve and base ends alternately in contact, so that the moderated region in a given cylinder was in the closest possible proximity to the moderated region in an adjacent cylinder. All cylinders were considered to be lying on a concrete pad one meter thick. Moderation was varied to obtain the optimum H/U ratio. Worst-case external reflection/moderation conditions were found by varying the density of the interstitial water between cylinders to simulate frost or snow. The calculation also assumed one cylinder above (touching) the array to simulate movement in/out/over the array.

For the 48Y cylinder, the condition that met the upper safety limit had an H/U ratio of 11.5 with an interstitial water density of 0.10 g/cm^3 (6.2 lb/ft^3). Thus, the maximum safe mass of hydrogen in each type product 48Y cylinder in an array was determined to be 1.05 kg (2.31 lb) present in the form of 9.5 kg (20.9 lb) of water.

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 0.25 g/cm^3 (15.6 lb/ft^3). Thus, the maximum safe mass of hydrogen in each type product 30B cylinder in an array was determined to be 0.95 kg (2.09 lb) present in the form of 8.5 kg (18.7 lb) of water.

Criticality safety of Type 48Y and 30B product cylinders depends on the control of moderator content. Criticality safety is achieved by ensuring that there is less than 1.05 kg (2.31 lb) of hydrogen present in a Type 48Y cylinder and less than 0.95 kg (2.09 lb) of hydrogen present in a Type 30B cylinder.

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 21.9 cm (8.6 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). There is a minimum edge separation of 180 cm (70.9 in) from any other fixed plant vessels that can accumulate enriched uranium. The pair of traps can thus be considered to be neutronically isolated from other fixed vessels.

Calculations were performed on the isolated pair of cold traps and were found to be substantially subcritical with k_{eff} = 0.8030. The calculations assumed an enrichment of 6.0 $^w/_o$, H/U of 7 and 2.5 cm (0.984 in) water reflection placed at the model boundary to simulate spurious reflection.

According to the restrictions on movement of mobile vessels, one vessel can come into contact with a trap but any others have to be kept at 60 cm (23.6 in) separation.

MONK8A (SA, 2001) calculations have been performed in which a vacuum cleaner is in contact with one 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 the same cold trap. These are typical of Separation Plant mobile vessels. Each mobile vessel was modeled with the appropriate uranic fill; the vacuum cleaner was filled with uranyl fluoride/water mixture with optimum moderation (H/U=12), and the vacuum pump (conservatively containing hydrocarbon oil) was filled with uranic breakdown of composition $UF_4 \cdot 10.5CH_2$. The resulting k_{eff} = 0.8229 shows a slight increase in reactivity with respect to the isolated pair of traps using the same conservative assumptions. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has high efficiency particulate air (HEPA) filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

Additionally, calculations were performed in which it was assumed that there are no movement controls, and both the vacuum cleaner and pump were in contact with one of the cold traps. Even with 2.5 cm (0.984 in) spurious water reflection placed around each unit, and at enrichment of 6.0 $^{w}/_{o}$, the result remained substantially subcritical with k_{eff} = 0.8673.

The cold traps have therefore been determined to be safe both as a pair in isolation and 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

These chemical traps of the Product Vent Subsystem are individually safe by diameter (20.3 cm (8.0 in) compared with the safe diameter of 21.9 cm (8.6 in) calculated for 6.0 $^{w}/_{o}$ enrichment). However, calculations have been performed concerning the effect of possible neutron interaction with nearby (uranium bearing) equipment.

In the MONK8A (SA, 2001) calculations for the Product Vent Subsystem, the plant spacing to the edge of the standby vent system is assumed to be 50 cm (19.7 in). The standby vent system has been included in the model. The traps were both assumed to fill entirely with uranyl fluoride/water with no restriction on water content. This is conservative, as in practice the H/U ratio of the uranyl fluoride in the traps will have a limiting upper value of 7. Also, the space within the trap, which would normally be occupied by carbon or alumina, is modeled as being filled with uranic material. This maximizes the mass of fissile material within the traps and provides added conservatism. The pump, alumina traps, oil trap and exhaust filter are assumed to be filled with uranyl fluoride/water of unlimited water content. This is conservative, as virtually no uranium is expected in these components.

Calculations were performed to account for interaction with other vessels in movement. According to the restrictions on movement, one mobile vessel can come into contact with one of the fixed chemical absorber traps, but other mobile vessels are assumed to be at 60 cm (23.6 in) separation. The case modeled was for a vacuum cleaner (of diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in)) to be brought into contact with the vacuum pump in the product vent array. One other item, a 14 L (3.7 gal) rotary vane pump, was placed at 60 cm (23.6 in) edge

spacing from the vacuum cleaner. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

The MONK8A (SA, 2001) calculation for the worst case, where all vessels were assumed to be entirely filled with uranyl fluoride/water mixture at optimum moderation, a trap and a vacuum cleaner are in contact with one of the fixed pumps, and all pumps were modeled with volumes of 14 L (3.7 gal), yields a k_{eff} = 0.9328.

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}.

The vacuum pump/chemical trap sets have been shown to be safe under normal operating conditions and credible abnormal operating conditions, for ^{235}U enrichments up to 6.0 $^{w}/_{o}$.

3.4.4.8.4 Product Pumping Train UF_6 Pumps

More than 200 cm (78.7 in) separates each Product Pumping Train in the plant from other uranium containing vessels, so only interaction with mobile components needs be considered. Additionally, when being removed for repair or maintenance, a UF_6 pump might pass near to another similar pump.

The currently planned pump combination unit consists of two Leybold pumps, models WS2000 series and WS500 series, positioned in a fixed frame. The WS500 series has an internal free volume of 8.52 L (2.25 gal), which is less than half of the maximum safe volume of 18 L (4.8 gal) at 6.0 $^{w}/_{o}$ enrichment. Therefore the WS500 series pump can be modeled conservatively as an isometric cylinder of the same volume. However, the WS2000 series pump has an internal free volume of 33 L (8.7 gal), which considerably exceeds the safe volume, and even exceeds the minimum critical volume of 24 L (6.3 gal). Although the WS2000 series pump has a larger than critical internal free volume, the shape of the internal volume is far from the optimum. Therefore, the WS2000 pump was modeled in some detail based on drawings supplied by the manufacturer.

MONK8A (SA, 2001) calculations were initially performed for an isolated pump combination to assess the intrinsic safety of the combination. The maximum k_{eff} of 0.7479 was achieved using an enrichment of 6.0 $^{w}/_{o}$ and an optimum H/U ratio of 12. From this analysis, the pump combination in isolation can be regarded as being intrinsically safe. As mentioned above, there is potential for a second pump unit to approach when being removed for maintenance. Calculations were performed on pairs of pumps in contact with each other, either side by side, or touching at the gearbox ends. The most reactive case was with the gearbox ends touching (k_{eff} = 0.8277), assuming an enrichment of 6.0 $^{w}/_{o}$ and an optimum H/U ratio of 10.

To consider interaction of mobile vessels, calculations were performed which added a vacuum cleaner to the pair of pumps, either in contact with the gearbox end (with the pumps side by side) or alongside one of the pumps (with the pumps touching at the gearbox ends). The worst case was achieved with the latter arrangement giving a $k_{eff} = 0.8444$.

A 14 L (3.7 gal) isometric cylinder representing an additional pump in transit was then placed 60 cm (23.6 in) from the vacuum cleaner resulting in a $k_{eff} = 0.8743$. This increase reflects the fact that the 14 L (3.7 gal) pump is the most reactive unit in the array; over 80% of fission events occur inside the 14 L (3.7 gal) pump. The relative orientation of the product pumps and vacuum cleaner has little effect on the value of k_{eff} when the 14 L (3.7 gal) pump is present. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

Even assuming the most conservative geometry and moderation conditions, k_{eff} remains substantially subcritical. 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 two pump units is safe at any spacing. No restriction is placed on the moderator content of the pump units.
- One pump or pump unit may be moved, and may approach another similar pump unit or vacuum cleaner (of safe diameter) at any orientation, and without spacing restrictions. Other pumps (of 14 L (3.7 gal) internal volume or less) must not approach within 60 cm (23.6 in) of a product pumping train. No restriction is placed on the moderator content of any of the vessels.

3.4.5 Tails Take-off System

The NEF Tails Take-off System uses a process similar to the original LES plant. The NRC staff previously reviewed the Claiborne Enrichment Center license application relative to the Tails Take-off System and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Tails Take-off System is provided in NUREG-1491 (NRC, 1994), Section 3.5. The primary differences are as follows:

A. Tails Take-off Cylinder Operating Temperature

The Claiborne Enrichment Center cylinder temperature was maintained at +3.9°C (39°F) by spraying the cylinders with chilled water. The NEF chills the cylinders to –25°C (-13°F) by using cold air from refrigeration units.

B. System Pressure (at the UBC)

The Claiborne Enrichment Center used a relatively high pressure of 225 mbar (3.26 psia) in the header to the cylinder. The high pressure was generated via two pump sets. The first pump set was in the "primary" header from each cascade and consisted of two pumps – a first stage and a second stage that were in series. There were seven cascades; therefore, there were 14 pumps total in the seven sets. After these seven pump sets, the discharges all combined into a single "secondary" header. In this secondary header, there were three high pressure vacuum pumps. These three were in parallel. The pressure (vacuum) at the cylinder for the NEF is substantially lower. It has been reduced to no greater than 80 mbar (32.1 in. H_2O). This lower vacuum is accomplished primarily because the cylinder is chilled to –25.0°C (–13°F). As with the Claiborne Enrichment Center, the tails pumping system for NEF uses two vacuum pumps in series for each cascade. There is a spare set of vacuum pumps for each cascade. These are in parallel arrangement. There is no high pressure pump in the secondary header.

C. Tails Evacuation Pump/Chemical Trap Set

The current system has a dedicated pump/chemical trap set for venting and does not use the Feed Purification System like the Claiborne Enrichment Center.

D. Cylinder Quantities

The Claiborne Enrichment Center contained a total of ten cylinders. There were five cooling stations, each with two cylinders. The NEF uses ten cylinders. However, each cylinder is in a dedicated LTTS.

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. 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. The system is shown in Figure 3.4-11, Process Flow Diagram Tails Take-off System.

Most of the light gases from the separation process are discharged into the product stream, so venting of the tails system is seldom necessary.

Small, intermittent quantities of gaseous effluent are produced from purging and venting the flexible piping used to connect the UBCs 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 Separations Building 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 TSB and reused.

The Tails Take-off System is located in the UF_6 Handling Area and Process Services Area of the Separations Building Module. The location of major equipment is shown on Figure 3.3-2, Separations Building Module, First Floor; Figure 3.3-3, UF_6 Handling Area, Equipment Location; and Figure 3.3-4, Separations Building Module, Second Floor. 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 major components of the Tails Take-off System 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. Each 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. A rubber bellows is fitted around the back opening, which envelops the cylinder valve, to prevent cooled air from leaking out of the Tails LTTS. A hot air blower is used to keep the valve and its surrounding area heated. The door frames, access port, rubber collar, and defrost condensate pipework 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 UBC.

E. Tails Evacuation Pump/Chemical Trap Set

The Tails Evacuation Pump/Chemical Trap Set consists of a carbon trap, an aluminum oxide trap, and an insulated vacuum pump with internal nitrogen purge and oil traps on either side. The exhaust from the pump goes to the Separations Plant GEVS.

The activated carbon trap removes small traces of UF_6. The aluminum oxide trap removes HF. Oil traps are installed before and after the pump to prevent oil migration both upstream and into the Separations Plant GEVS.

F. Assay Sampling Subsystem

Pipework 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/chemical trap set similar to the one described above.

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 consisting of eight cascades. The system is designed to continuously remove depleted UF_6 (tails) from the cascades under all operating conditions. The maximum tails flow is 168 kg/hr (370 lb/hr) based on a maximum capacity of 545,000 SWU/year (produced by each Cascade Hall). Peak flow rates could be as high as 256 kg/hr (564 lb/hr) for UF_6 removal from the cascades under abnormal 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 that UF_6 exiting the system. This important safety feature greatly limits the likelihood of worker and public exposures.

There are ten Tails LTTSs for each Cascade Hall. Of these ten, 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 other two 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 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 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. Separations Building GEVS

F. Electrical System

G. Hoisting and Transportation Equipment.

3.4.5.5 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 Tails Take-off System operate at subatmospheric 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 Separations Building GEVS remove any releases from the work area.

D. Before discharge to the Separations Building 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. 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 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 fully fluorinated synthetic oil such as "Fomblin," a perfluorinated polyether (PFPE).

I. Temperature in the Tails Evacuation Pump/Chemical Trap Set carbon 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. A Cascade Hall's normal maximum capacity is based on 545,000 SWU/yr. 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. 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, 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 less than 2 mbar (0.8 in. H_2O). First alarm level (H) is a high level to give operator warning of high pressure. Second alarm level (HH) signals that the tails 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 less than 4 mbar (0.8 in. H_2O). First alarm level (H) gives operator warning of high pressure. Second alarm level (HH) trips the vacuum pump off-line to protect the cascade from air ingress. A third alarm at 80 mbar 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 less than 55 mbar (22.1 in. H_2O). The first alarm level provides operator warning of high pressure at 70 mbar (28.1 in. H_2O). At the second alarm level, 80 mbar (32.1 in. H_2O) on two of three sensors, the vacuum pump trips off-line and a signal that the tails 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 between 5 and 50 mbar (2 and 20 in H_2O). The first alarm level is 70 mbar (28.1 in H_2O) to give operator warning of high pressure. The second alarm level at 80 mbar (32.1 in H_2O) 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. A weight of less than 800 kg (1,764 lb) indicates no cylinder present in the Tails LTTS. 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 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 monitors the circulating air temperature. This sensor and local control maintains the Tails LTTS temperature to a normal value of –25°C (-13°F). 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 –5°C from –25°C (23°F from -13°F). 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 measures the circulating air temperature and is fail-safe hardwired. The second measures the air inside the Tails LTTS and is a fail-safe capillary device. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above set points. Set point on the hardwired instrument is 50°C (122°F) and set point on the capillary instrument is 53°C (127°F). If heater trip occurs from these two instruments, the Tails LTTS is automatically taken off-line and put into a standby mode.

To prevent desublimation in the cylinder valve, hot air is blown over the valve with a hot air blower. A temperature sensor on the valve controls the temperature to 63°C (145°F).

E. Tails Evacuation Pump/Chemical Trap Set

To prevent the carbon trap from overheating and overfilling with UF_6, there are two instruments. One sensor monitors the carbon trap temperature. This sensor will close the Tails LTTS vent valve when carbon trap temperature exceeds 42°C (108°F). This blocks flow to the vacuum pump/chemical trap set. The carbon trap also has a weigh system. In addition to local weight display, this system will shut down the vacuum pump when the high weight set point is reached.

The activated aluminum oxide (Al_2O_3) trap on the vacuum pump/chemical trap set is also 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 used to monitor accumulation of UF_6 in the carbon trap and HF in the aluminum oxide trap. The chemical traps are replaced based on the accumulated weight.

3.4.6 Product Blending System

The NEF Product Blending System uses a process similar to the original LES plant. The NRC staff previously reviewed the Claiborne Enrichment Center SAR application relative to the Product Blending System and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Product Blending System is provided in NUREG-1491 (NRC, 1994), Section 3.6. The primary differences are as follows:

A. Blending Donor Station Operating Conditions.

The Claiborne Enrichment Center used a Donor Station that operated above atmospheric pressure. UF_6 in the donor cylinder was maintained in the liquid phase. Normal UF_6 pressure in the feed cylinder was above atmospheric, at 2.5 bar (36.3 psia). Normal station heating temperature was up to 110°C (230°F). The Claiborne Enrichment Center used a sealed autoclave for secondary confinement of the donor cylinder to prevent exposure in the event a leak developed in the primary confinement barrier (cylinder and piping).

The NEF sublimes solid UF_6 directly to gaseous UF_6 at subatmospheric pressure, without entering the liquid phase. Normal donor cylinder pressure is 500 mbar (7.25 psia) and the station temperature during heating is limited to 61°C (142°F). As a result, a Blending Donor Station is used to heat the donor cylinder rather than an autoclave.

B. Blending Receiver Station Operating Temperature.

The Claiborne Enrichment Center cylinder temperature was maintained at +10°C (50°F). Cool air from a central system was used to maintain the temperature of the receiver stations. The NEF will chill the cylinder to –25°C (-13°F) by using cold air from a refrigeration unit integral to the Blending Receiver Station.

Other differences are the use of only four receiver stations in this process versus five in the original and the use of a dedicated vacuum pump/chemical trap set in the current design versus a mobile set in the original.

3.4.6.1 Functional Description

The primary function of the Product Blending System is to provide a means to fill 30B cylinders with UF_6 at a specified ^{235}U concentration. 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. The system is shown in Figure 3.4-12, Process Flow Diagram Product Blending System.

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 Separations Building 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 TSB for reuse.

The Product Blending System is located in the Blending and Liquid Sampling Area of the Separations Building. The location of major equipment is shown on Figure 3.3-10, Cylinder Receipt and Dispatch Building, First Floor, Part A. It is 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 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. A hot air blower directed at the cylinder valve 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. A rubber bellows is fitted around the back opening, which envelops the cylinder valve, to prevent cooled air from leaking out of the Blending Receiver Station. Similar seals on the other 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 at –60°C (-76°F) 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 Separations Building 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 in front of the vacuum pump. Weigh cells are installed on the carbon trap and the aluminum oxide trap to indicate the accumulated mass in each without the need to remove the trap for weighing. Oil traps are installed before and after the vacuum pump to prevent diffusion of oil, both back into the Blending and Sampling Vent System and forward into the Separations Building 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 per year 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 four 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. Separations Building 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 Separations Building GEVS is provided any time a UF_6 line is disconnected.

E. Before discharge to the Separations Building 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 fully fluorinated synthetic oil such as "Fomblin," a perfluorinated polyether (PFPE).

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 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.

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 via 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 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 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. Normal air temperature in the Blending Donor Station during heating ranges from ambient to 61°C (142°F), while the cylinder temperature ranges from ambient to 53°C (127°F). The first alarm level 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. The second alarm level is 55°C (131°F) for the cylinder, which trips the Blending Donor Station heater off.

In addition to the above temperature controls, the Blending Donor Station has two independent and diverse temperature protection instruments. One is hard wired and measures cylinder temperature, and the other is a capillary type and measures the Blending Donor Station air temperature. These provide extra safety margin to prevent overheating the cylinder if the air temperature control fails. Both systems automatically de-energize the air heater and blower, if either the cylinder temperature reaches 55°C (131°F) or the Blending Donor Station air temperature reaches 63°C (145°F).

The donor cylinder pressure is monitored with dual sensors to prevent over-pressurization. Normal header pressure is limited to 500 mbar (7.25 psia). The first alarm level is 600 mbar (8.7 psia) to give operator warning of high pressure. The second alarm level at 850 mbar (12.3 psia) automatically closes the cylinder valve and trips the Blending Donor Station off-line. A low pressure alarm at 200 mbar (2.9 psia) 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 cylinder. The first weight trip at 800 kg (1,764 lb) gross is used to indicate a cylinder is present in the Blending Donor Station. The 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 800 kg (1,764 lb) gross 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). A first alarm level at 550 mbar (7.98 psia) warns the operator of high pressure. A second alarm level at 650 mbar (9.43 psia) 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 of –25°C (-13°F). 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 to –5°C from –25°C (23° F from -13°F). 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 measures the circulating air temperature and is fail-safe hardwired. The second measures the air inside the Blending Receiver Station and is a fail-safe capillary device. Both of these instruments will trip the defrost heater and fan power supply in the event the air temperature rises above set points. Set point on the hardwired instrument is 50°C (122°F) and set point on the capillary instrument is 53°C (127°F). If heater trip occurs from these two instruments, the Blending Receiver Station is automatically taken off-line and the transfer sequence stopped.

To prevent desublimation in the cylinder valve, hot air is blown over the valve with a hot air blower. A temperature sensor on the valve controls the temperature to 63°C (145°F).

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 first high alarm, at 70 mbar (28.1 in. H_2O), warns of high pressure in the UF_6 cold trap. A first low alarm, at 20 mbar (8.03 in. H_2O), 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 (gas-back). A second low alarm, at 1 mbar (0.401 in. H_2O), closes the UF_6 cold trap outlet valve to prevent UF_6 flow to the vacuum pump. A second high alarm, at 80 mbar (32.1 in. H_2O), trips the UF_6 cold trap off-line, switching the heater/chiller unit off and closing the inlet/outlet valves.

A weighing system monitors the UF_6 contents of the UF_6 cold trap. A first alarm at 20 kg (44.1 lb) warns that the UF_6 cold trap is full. At 25 kg (55.1 lb) 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 controlled at –60°C (-76°F) during cooling to desublime any UF_6 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 at –63°C (-81.4°F) warns of a chiller unit fault. A first high alarm at –52°C (-61.6°F) closes the UF_6 cold trap outlet valve and a second high alarm at 25°C (77°F) warns of high temperature during gas-back. At 30°C (86°F) 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 are two instruments. One sensor monitors the carbon trap temperature. This sensor will close the UF_6 cold trap outlet valve when carbon trap temperature exceeds 42°C (108°F). This blocks flow to the Vacuum Pump/Chemical Trap Set. This sensor will also provide an automatic trip of the associated vacuum pump on carbon trap high temperature. The carbon trap also has a weigh system. In addition to local weight display, this system will shut down the vacuum pump when the high weight set point is reached.

The activated aluminum oxide trap on the vacuum pump/chemical trap set is also 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 used to monitor accumulation of UF_6 in the carbon trap and HF in the aluminum oxide trap. The traps are replaced based on the accumulated weight.

3.4.6.8 Criticality Safety

3.4.6.8.1 Product Cylinders

Calculations were performed on infinite two-dimensional arrays of full 48Y or 30B product cylinders. Inside each cylinder a region of UO_2F_2/water mixture was located. The remainder of the interior of the cylinder was assumed to be filled with 6.0 $^{w}/_{o}$ ^{235}U enriched UF_6. Cylinders in the arrays were placed with the valve and base ends alternately in contact, so that the moderated region in a given cylinder was in the closest possible proximity to the moderated region in an adjacent cylinder. All cylinders were considered to be lying on a concrete pad one meter thick. Moderation was varied to obtain the optimum H/U ratio. Worst-case external reflection/moderation conditions were found by varying the density of the interstitial water between cylinders to simulate frost or snow. The calculation also assumed one cylinder above (touching) the array to simulate movement in/out/over the array.

For the 48Y cylinder, the condition that met the upper safety limit had an H/U ratio of 11.5 with an interstitial water density of 0.10 g/cm^3 (6.2 lb/ft^3). Thus, the maximum safe mass of hydrogen in each type product 48Y cylinder in an array was determined to be 1.05 kg (2.31 lb) present in the form of 9.5 kg (20.9 lb) of water.

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 0.25 g/cm^3 (15.6 lb/ft^3). Thus, the maximum safe mass of hydrogen in each type product 30B cylinder in an array was determined to be 0.95 kg (2.09 lb) present in the form of 8.5 kg (18.7 lb) of water.

Criticality safety of Type 48Y and 30B product cylinders depends on the control of moderator content. Criticality safety is achieved by ensuring that there is less than 1.05 kg (2.31 lb) of hydrogen present in a Type 48Y cylinder and less than 0.95 kg (2.09 lb) of hydrogen present in a Type 30B cylinder.

3.4.6.8.2 UF_6 Cold Trap

Although the cold trap has a large internal volume it is 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 21.9 cm (8.6 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 a cold trap 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 has a minimum edge separation of 180 cm (70.9 in) from any other fixed plant vessels that can accumulate enriched uranium. The cold trap can thus be considered to be neutronically isolated from other fixed vessels.

According to the restrictions on movement of mobile vessels, one vessel can come into contact with a trap but any others have to be kept at 60 cm (23.6 in) separation.

MONK8A (SA, 2001) calculations have been performed in which a vacuum cleaner is in contact with the cold trap, and another vessel (a 14 L (3.7 gal) product vent vacuum pump) is at 60 cm (23.6 in) edge spacing from the cold trap. These are typical of Separation Plant mobile vessels. Each mobile vessel was modeled with the appropriate uranic fill; the vacuum cleaner was filled with uranyl fluoride/water mixture with optimum moderation (H/U=12), and the vacuum pump (conservatively containing hydrocarbon oil) was filled with uranic breakdown of composition $UF_4 \cdot 10.5CH_2$. The resulting k_{eff} = 0.8229 shows a slight increase in reactivity with respect to the isolated cold trap using the same conservative assumptions. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

Additionally, calculations were performed in which it was assumed that there are no movement controls, and both the vacuum cleaner and pump were in contact with the cold trap. Even with 2.5 cm (0.984 in) spurious water reflection placed around each unit, and at enrichment of 6.0 $^{w}/_{o}$, the result remained substantially subcritical with k_{eff} = 0.8673.

The cold trap has therefore been determined to be safe both in isolation and while interacting with other fixed plant or vessels in movement for ^{235}U enrichments up to 6.0 $^{w}/_{o}$.

3.4.6.8.3 Vacuum Pump / Chemical Trap Set

These chemical traps of the Blending and Sampling Vent Subsystem are individually safe by diameter (20.3 cm (8.0 in) compared with the safe diameter of 21.9 cm (8.6 in) calculated for 6.0 $^{w}/_{o}$ enrichment). However, calculations have been performed concerning the effect of possible neutron interaction with nearby (uranium bearing) equipment.

In the MONK8A (SA, 2001) calculations, the traps were both assumed to fill entirely with uranyl fluoride/water with no restriction on water content. This is conservative, as in practice the H/U ratio of the uranyl fluoride in the traps will have a limiting upper value of 7. Also, the space within the trap, which would normally be occupied by carbon or alumina, is modeled as being

filled with uranic material. This maximizes the mass of fissile material within the traps and provides added conservatism. The pump, alumina traps, oil trap and exhaust filter are assumed to be filled with uranyl fluoride/water of unlimited water content. This is conservative, as virtually no uranium is expected in these components.

Calculations were performed to account for interaction with other vessels in movement. According to the restrictions on movement, one mobile vessel can come into contact with one of the fixed chemical absorber traps, but other mobile vessels are assumed to be at 60 cm (23.6 in) separation. The case modeled was for a vacuum cleaner (of diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in)) to be brought into contact with the vacuum pump in the product vent array. One other item, a 14 L (3.7 gal) rotary vane pump, was placed at 60 cm (23.6 in) edge spacing from the vacuum cleaner. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

The MONK8A (SA, 2001) calculation for the worst case, where all vessels were assumed to be entirely filled with uranyl fluoride/water mixture at optimum moderation, a trap and a vacuum cleaner are in contact with the fixed pump, and the pump volume is 14 L (3.7 gal), yields a $k_{eff} = 0.9328$.

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}.

The vacuum pump/chemical trap set has been shown to be safe under normal operating conditions and credible abnormal operating conditions, for ^{235}U enrichments up to 6.0 $^{w}/_{o}$.

3.4.7 Product Liquid Sampling System

The NEF Product Liquid Sampling System uses a process essentially the same as the Claiborne Enrichment Center. The NRC staff previously reviewed the Claiborne Enrichment Center license application relative to the Product Liquid Sampling System and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Product Liquid Sampling System is provided in NUREG-1491 (NRC, 1994), Section 3.6. The use of a dedicated vent system, the Blending and Sampling Vent Subsystem, rather than a mobile unit as in the Claiborne Enrichment Center, is the only appreciable difference.

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. 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 (current version at the time of autoclave manufacture), with the exception that the pressure relief devices specified in Sections UG-125 through 137 are not be 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. There is also a viewing port in the door head.

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 water supplied from the Chilled Water Distribution System.

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 five Liquid Product Sampling Autoclaves at the NEF.

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 Separations Building 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. Separations Building GEVS

C. Chilled Water Distribution System

D. Nitrogen System

E. Compressed Air System

F. Electrical System

G. Hoisting and Transportation Equipment

H. 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 Separations Building GEVS is provided any time the autoclave is opened or the sample manifold is disconnected.

H. Before discharge to the Separations Building 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.

The air quality of each autoclave is monitored for the presence of HF. If HF is detected, indicating a breach in the primary containment (cylinder or sampling manifold), the autoclave vent valve and the door are prevented from opening. A second HF monitor in the common vent header from the autoclaves to the Separations Building GEVS provides a backup check to verify the quality of the air venting from the autoclave. If HF is detected here, an alarm signals to manually close the 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.

3.4.8 Contingency Dump System

The NEF Contingency Dump System uses a similar process to the original Claiborne Enrichment Center. The NRC staff previously reviewed the Claiborne Enrichment Center SAR application relative to the Contingency Dump System and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public

health and safety. The specific discussion on the Contingency Dump System is provided in NUREG-1491 (NRC, 1994), Section 3.5. The primary differences are:

A. The number of chemical traps has been increased to three per cascade.

B. Pumping systems supporting the traps have been dedicated to single cascades rather than per assay unit.

These changes reflect the increased cascade size.

3.4.8.1 Functional Description

The 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.

The Contingency Dump System is shown in Figure 3.4-15, Process Flow Diagram Contingency Dump System.

The Contingency Dump System forms only part of the dumping philosophy. 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 Contingency Dump System is 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 Separations Building GEVS.

3.4.8.2 Major Components

The major components of the Contingency Dump System 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 filled with sodium fluoride (NaF). An NaF trap is shown in Figure 3.4-16, NaF Trap Equipment Drawing. 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.

Manual valves are fitted to the inlet and the outlet of the NaF traps and buffer volume to act as protective barriers during maintenance activities. 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 major components of the Contingency Dump System Vacuum Pump/Chemical Trap Set are:

- A roots type and rotary vane vacuum pump
- Activated carbon trap
- 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, activated carbon trap, aluminum oxide traps and sliding vane type vacuum pump. The sliding vane vacuum pump discharges through a final oil trap into the Separations Building 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 Separations Building 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 trap is to remove small traces of UF_6 and the aluminum oxide trap is to remove any HF from the gas flow. These traps are fitted upstream of the sliding vane vacuum pump. A second, smaller, aluminum oxide trap, is fitted immediately before the sliding vane vacuum pump. This trap prevents back diffusion of oil from the vacuum pump into the traps. The pump discharge trap prevents oil entering the Separations Building GEVS.

In order to measure any accumulated mass within the activated carbon trap and aluminum oxide trap a local facility for weighing each trap without disturbing the process is provided.

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 with no installed redundancy.

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 are 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. Separations Building GEVS

C. Nitrogen System

D. Compressed Air System

E. Electrical System

F. Plant Control 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 Separations Building GEVS remove any releases from the work area.

D. Before discharge to the Separations Building 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 fully fluorinated synthetic oil such as "Fomblin," a perfluorinated polyether (PFPE).

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 at the Contingency Dump System is eliminated by ensuring a safe design. Both the NaF traps and the buffer volume are designed and installed to be geometrically safe.

K. Weight in the contingency dump vent vacuum dump/chemical trap set carbon trap is monitored and a trip on weight stops the contingency dump vent vacuum pump.

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 activated carbon 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 activated carbon trap. The carbon trap also has a weigh system. In addition to local weight display, this system will shut down the vacuum pump when the high weight set point is reached.

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

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 will be 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 inside diameter of approximately 54 cm (21.3 in).

MONK8A (SA, 2001) calculations have been carried out first for an isolated trap with 2.5 cm (0.984 in) of water reflection around the trap body. The model assumed that adsorbed UF_6 within the trap is converted to $UO_2F_2 \cdot 3.5H_2O$, i.e., the accident condition with air inleakage. The uranium enrichment was 1.5 $^{w}/_{o}$ ^{235}U. The value of k_{eff} obtained was 0.6466. The model represents a UF_6 loading in the trap of approximately 220 kg (485 lb), which would require many dumps to achieve. Contingency dump traps are thus intrinsically safe by a very large margin.

Considering interaction between the three closely spaced traps, criticality safety is demonstrated by comparison with the MONK8A (SA, 2001) calculations for storage of contingency dump traps in unspaced linear arrays. The calculation modeled a linear array of seven touching dump traps with three other vessels at 60 cm (23.6 in) spacing from the array (a residue container, a vacuum cleaner cylinder and a UF_6 pump unit). An additional dump trap was also placed in contact with the center trap of the linear array. The value of k_{eff} obtained was 0.8537. The modeled arrangement is more conservative than three spaced traps interacting with the same mobile vessels and it can be concluded that contingency dump traps are safe when interacting with any mobile vessels that are likely to be present. The vacuum cleaner was assumed to be a cleaner of internal diameter 20.3 cm (8.0 in) and length 66 cm (26.0 in) and

was assumed to be entirely filled with uranic material with an enrichment of 6.0 $^{w}/_{o}$. MONK8A (SA, 2001) calculations have been carried out for an isolated cylinder using these dimensions, filled with uranyl fluoride/water at optimum moderation and with 2.5 cm (0.984 in) water reflection. This gave a value for k_{eff} of 0.8037. The cleaner has HEPA filtration on the exhaust, and will be dedicated for cleaning operations where uranic material is involved and will be marked clearly.

3.4.9 Gaseous Effluent Vent Systems

The function of the GEVS is to remove particulates containing uranium, and HF from potentially contaminated process gas streams. Prefilters and absolute filters (HEPA) remove particulates and potassium carbonate impregnated activated carbon filters are used for the removal of any HF. Electrostatic filters remove oil vapor from the gaseous effluent associated with exhaust from vacuum pump/chemical trap set outlets wherever necessary.

The systems produce solid wastes from the periodic replacement of prefilters, absolute filters, and chemical filters. The systems produce no gaseous effluents of their own, but discharge effluents from other systems after treatment to remove hazardous materials.
There are two GEVSs for the plant. The Separations Building GEVS and the TSB GEVS. Applicable codes and standards are given in Table 3.4-14, Gaseous Effluent Vent System Codes and Standards.

3.4.9.1 Separations Building Gaseous Effluent Vent System

The GEVS for the Separations Building provides exhaust of potentially hazardous contaminants. The system is shown on Figure 3.4-17, Process Flow Diagram Gaseous Effluent Vent System Separations Building, Sheets 1 and 2.

The GEVS system serving the Separations Building is located in the TSB on the first floor. The system is operated from the Control Room.

3.4.9.1.1 Functional Description

The Separations Building GEVS interfaces with the following systems, auxiliary activities, and utilities:

A. UF_6 Feed System

B. Product Take-off System

C. Tails Take-off System

D. Product Blending System

E. Product Liquid Sampling System

F. Contingency Dump System

G. Compressed Air System

H. Electrical System

I. Control Room

The design requirements 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.

3.4.9.1.2 Major Components

The Separation Building GEVS consists of the following major components.

A. Duct system

B. Electrostatic filter

C. Prefilters

D. High Efficiency Particulate Air (HEPA) Filters

E. Activated carbon filters

F. Centrifugal Fans

G. Monitoring and controls (HF) before and after filters

H. Automatically controlled inlet and outlet isolation dampers

I. Exhaust stack

J. Gamma monitors and controls (prefilters, HEPA Filters, and electrostatic precipitator)

K. Monitoring and controls (alpha and HF) in exhaust stack

L. Stack sampling system.

3.4.9.1.3 Design Description

The design bases and specifications are given in Table 3.4-15, GEVS Design Bases (Separations Building).

One Separation Building GEVS serves the entire Separations Building. It consists of a duct network that serves all of the uranium processing systems and operates at negative pressure. It is sized to handle the flow from all permanently ducted process locations, as well as up to 13 flexible exhaust hose exhaust points at one time. The flexible exhaust hoses are used for cylinder connection/disconnection or maintenance procedures. A minimum velocity of 12.7 m/s (2500 ft/min) is maintained in the duct system in order to ensure that particulate contaminants are conveyed through the ductwork without settling. Each section of the duct system has an orifice plate to maintain a minimum air velocity. Each section also has a damper to balance the individual flows in the system. The flexible exhaust hoses will have a capture velocity of 0.75 m/s (148 ft/min).

The ductwork is connected to two parallel filter stations. Each is capable of handling 100% of the effluent. One is online and the other is a standby. Each station consists of an 85% efficient prefilter, a 99.97% efficient HEPA filter, and a 99% efficient activated carbon filter for removal of HF. Electrostatic filters have an efficiency of 97%. The filter stations vent through one of two fans. Each fan is capable of handling 100% of the effluent. One fan is online, and the other is a

standby. A switch between the operational and standby systems can be made using automatically controlled dampers. The system capacity is estimated to be 11,000 m^3/hr (6,474 cfm). A differential pressure controller controls the fan speed and maintains negative pressure upstream of the filter station. Flow rates and capacity are preliminary and are subject to change during final design.

Gases from the UF_6 processing systems pass through the prefilter which removes dust and protects the HEPA filter, then through the HEPA filter which removes uranium aerosols (mainly UO_2F_2 particles), then through the potassium carbonate impregnated activated carbon filters which captures HF. The remaining clean gases pass through the fan, which maintains the negative pressure upstream of the filter stations. Finally, the clean gases are discharged through a roof top exhaust stack on the TSB. One exhaust stack is common to the operational system and the standby system.

The materials of construction, corrosion allowances, and fabrication specifications for the equipment and ductwork used in the GEVS are compatible with UF_6 and HF and are noncombustible.

The Separations Building GEVS provides the ventilation and hazardous contaminant removal for the following systems, equipment, and areas.

It is connected via permanently ducted locations to:

A. The UF_6 Feed System, The Product Take-off System, the Tails Take-off System, the Product Blending and Sampling Vent Subsystem and Contingency Dump System.

B. All Liquid Sampling System autoclaves.

C. All discharge lines from mobile vacuum pump sets.

It is connected via flexible exhaust hoses to places where piping is normally disconnected or equipment is opened, such as:

A. The Product Take-off System and Tails Take-off System pumping trains and the UF_6 Feed Purification Subsystem, Product Vent Subsystem, Tails Evacuation Subsystem and Product Blending and Sampling Vent Subsystem vacuum pump/ chemical trap sets.

B. The Liquid Sampling System autoclaves. The lines for the flexible duct are run to a point within approximately 0.9 m (3 ft) of each door opening. Approximately 1.8 m (6 ft) of flexible duct is connected to this point to enable access to all places where the autoclave UF_6 pipework is connected/disconnected.

C. The Product and Tails Low Temperature Take-off Stations.

D. The Solid Feed Stations and Feed Purification Low Temperature Take-off Stations.

E. The Blending Donor Stations and Blending Receiver Stations.

If the Separations Building GEVS stops operating, material within the duct will not be released into the building because each of the Separations Building GEVS connections has a P-trap to catch entrained material that could otherwise fall back into the building from the ductwork during system failure.

Mobile vacuum pump units that vent to the Separations Building GEVS are available in the UF_6 Handling Areas and the Product Blending and Liquid Sampling Area.

3.4.9.1.4 Design and Safety Features

The Separations Building GEVS is designed to protect plant personnel against uranium and HF exposure. Potential hazards include the release of UF_6 and HF to the building and/or environment, contaminated filters, and contaminated oil.

The system filters contaminated gases, and continuously monitoring exhaust gas flow to the atmosphere. HF monitors and alarms are installed upstream of the filtration systems and immediately upstream of the exhaust stack to avoid the release of hazardous materials to the environment. A fault alarm is generated, in the event of a fault occurring within any of the monitors. The alarms are monitored in the Control Room.

Gamma monitors measure the build up of ^{235}U on prefilters, HEPA filters and on the electrostatic filter. Upon detection of high-high gamma levels in the Separations Building GEVS filter, the operating Separations Building GEVS train trips. Upon detection of high-high gamma levels in the Separations Building GEVS electrostatic precipitator, the trip realigns dampers to bypass and isolate the electrostatic precipitator.

The Separations Building GEVS unit is located in a dedicated room with the GEVS from the TSB. The filters are bag-in/bag-out. The frequency of filter replacement will be determined during the design phase and this section will be revised accordingly.

The Separations Building GEVS provides for continuous monitoring and periodic sampling of the gaseous effluent in the exhaust stack in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).

The Separations Building GEVS is designed to meet all applicable NRC requirements for public and plant personnel safety and effluent control and monitoring. The system designs also comply with applicable standards of OSHA, EPA, and state and local agencies.

The design and in-place testing of the Separations Building GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes potassium carbonate impregnated activated charcoal filters for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated charcoal filters for radioiodine removal are not applicable. The prefilter efficiency (85%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1 (ASME, 1997). The impregnated charcoal filter efficiency (99%) for removal of HF is based on Urenco specifications. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001). Qualification testing, to verify HF removal efficiency, of the impregnated charcoal will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated charcoal filter of charcoal samples will be performed on an annual basis. Throughout the useful life of the impregnated charcoal, 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 charcoal bed for removal of HF.

3.4.9.1.5 Instrumentation

The process variables, pressure, fan speed, and damper positioning are all controlled automatically. 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, devices are used to measure the level of radiological contamination (alpha only) present in the air stream located in the exhaust stack. Deviations from specified values are indicated by alarms. HF monitors and alarms are installed upstream of the filtration system and immediately upstream of the exhaust stack to avoid 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.

HF monitors and alarms are installed upstream of the filtration systems and immediately upstream of the exhaust stack to prevent the release of hazardous materials.

The differential pressure across the prefilter and HEPA filter is monitored to indicate required filter changes.

The GEVS control system is mounted in a Local Control Center (LCC). This is a stand-alone system that does not generate alarms during normal operation. The LCC provides automatic control of the fans and dampers and provides local control via a Local Operator Interface (LOI) that is mounted in the LCC.

The Central Control System (CCS) has no supervisory control over the Separations Building GEVS control system. However, the Separations Building GEVS LCC communicates with the CCS via the dual redundant process network so that comprehensive monitoring of the GEVS status exists. Data that is monitored is fans status, filter and duct pressure measurements, damper status, and electrostatic precipitator status. System alarms are relayed to the CCS.

The Separations Building GEVS LCC has one PLC that provides all automatic control and protection required for the system, and also the communication interface to the PCS. All equipment related to the Separations Building GEVS is directly wired to the LCC.

The radiological activity and HF monitoring instruments are stand-alone and powered separately. These instruments interface with the Separations Building GEVS LCC via hardwired signals that indicate when alarm limits have been exceeded. These alarms are overridden during calibration.

3.4.9.1.6 Criticality Safety

There are two sources of uranic material to the Separations Building GEVS, flexible exhaust hoses and rotary pump exhausts.

The rotary pump exhaust gas arising from the Product Vent Subsystem passes from the UF_6 cold trap through the activated carbon trap and alumina trap and finally through the rotary pump.

Excessive carry over from the cold trap to the carbon trap is avoided by the closure of a valve in the interconnection by a low pressure or a high temperature trip in the cold trap. The exhaust gas then passes through a trap filled with carbon that reacts irreversibly with the UF_6 and then passes through an activated alumina to remove HF. The gas is then pumped out into the Separations Building GEVS for final clean up. These chemical traps are replaced at regular intervals or when the weight indicators show that there is significant build up of material. A

weight trip on the carbon trap isolates the process line from the Separations Building GEVS when the traps are about to become saturated.

The flexible exhaust hoses will be used to support product (and feed and tails) cylinder and pump changeout and maintenance activities in the separations plant and trace enriched particulate matter may be released.

The potentially oil bearing inflow to the Separations Building GEVS from the rotary vacuum pumps exhausts is first passed through an electrostatic precipitator to remove the aerosol oil before joining the rest of the effluent gas. It then passes through pre filters, HEPA filters for particulates removal and impregnated carbon filters for removing HF. Prior to the HEPA filters there is a fluoride monitor that will alarm if the concentration of the fluorine compounds within the air being drawn into the filters exceeds a pre-determined level. This will provide assurance that accumulation of uranium in the filters is not occurring. The filters are equipped with differential pressure indicators and ^{235}U selective gamma monitors that will trip on blockage or build-up of material. The amount of uranium in the electrostatic precipitator will also be monitored for gamma radiation to ensure that any slow, chronic accumulation of fissile material does not pose a hazard.

The carbon trap weight trip and Separations Building GEVS filter gamma detector are installed to prevent any potential for criticality. In addition, the accumulation rate of uranium in the Separations Building GEVS is very low compared with the safe mass of 12.2 kg U (26.9 lb U) assuming double batching and all the uranium were enriched to 6.0 $^{w}/_{o}$. These low accumulations coupled with the weight trip and gamma detectors render a criticality accident in the Separations Building GEVS highly unlikely.

3.4.9.2 Technical Services Building GEVS

The TSB GEVS provides exhaust of potentially hazardous contaminants. The system is shown on Figure 3.4-18, Process Flow Diagram Gaseous Effluent Vent System Technical Services Building, Sheets 1 and 2.

The GEVS servicing the TSB is located on the first floor of the TSB and is monitored from the Control Room.

3.4.9.2.1 Functional Description

Potentially contaminated exhaust air comes from the following rooms and services within the TSB:

Ventilated Room	2,700 m^3/hr	(1,589 cfm)
Laundry	1,000 m^3/hr	(589 cfm)
Fomblin Oil Recovery System	2,000 m^3/hr	(1,177 cfm)
Decontamination Workshop	12,300 m^3/hr	(7,240 cfm)
Chemical Laboratories	1,000 m^3/hr	(589 cfm)
Cylinder Preparation Room	1,000 m^3/hr	(589 cfm)
Solid Waste Collection Room	700 m^3/hr	(412 cfm)

Air from the Fomblin Oil Recovery System is part of the Decontamination Workshop discharge. Thus, the total airflow to be handled by the TSB GEVS is 18,700 m^3/hr (11,000 cfm). Flow rates and capacities are preliminary and are subject to change during final design.

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.

3.4.9.2.2 Major Components

The TSB GEVS consists of the following major components.

A. Duct system

B. Prefilter

C. HEPA filter

D. Impregnated carbon filter (impregnated with potassium carbonate)

E. Centrifugal Fan

F. Monitoring and controls (HF) before and after filters

G. Automatically controlled inlet and outlet isolation dampers

H. Exhaust stack

I. Gamma monitor and controls (prefilter and HEPA filter)

J. Monitoring and controls (alpha and HF) in exhaust stack

K. Stack Sampling system.

3.4.9.2.3 Design Description

The design bases and specifications are given in Table 3.4-16, Gaseous Effluent Vent System Design Bases (Technical Services Building).

The GEVS serving the TSB consists of a duct network that serves all of the uranium processing systems and operates at negative pressure. The ductwork is connected to one filter station and vents through one fan. Both the filter station and the fan can handle 100% of the effluent. There is no standby filter station or fan. Operations that require the GEVS to be operational are shut down if the system shuts down. The system capacity is estimated to be 18,700 m^3/hr (11,000 cfm). A differential pressure controller controls the fan speed and maintains negative pressure in front of the filter station.

Gases from the UF_6 processing systems pass through the 85% efficient prefilter which removes dust and protects the HEPA filter, then through the 99.97% efficient HEPA filter which removes

uranium aerosols (mainly UO_2F_2 particles). Finally the air passes through the 99% efficient activated carbon (potassium carbonate impregnated) filter which captures HF. The remaining clean gases pass through the fan, which maintains the negative pressure upstream of the filter stations. The clean gases are then discharged through the exhaust stack on the TSB.

A minimum velocity of 12.7 m/s (2,500 ft/min) is maintained in the duct system in order to ensure that particulate contaminants are conveyed through the ductwork without settling. Each section of the duct system has an orifice plate to maintain a minimum air velocity. Each section also has a damper to balance the individual flows in the system. Flexible exhaust hoses have a capture velocity of 0.75 m/s (150 ft/min). Fume hoods shall have a capture velocity of 0.5 m/s (100 ft/min).

The TSB GEVS provides ventilation and hazardous contaminant removal for the TSB through ductwork, via hoods vented by booster fans to the technical services area, the chemical laboratory, and the vacuum pump rebuild workshop.

The materials of construction, corrosion allowances, and fabrication specifications for the equipment and ductwork used in the GEVS are compatible with UF_6 and HF and are noncombustible.

3.4.9.2.4 Design and Safety Features

The TSB GEVS is designed to protect plant personnel against uranium and HF exposure.

The TSB GEVS is designed to meet all applicable NRC requirements for public and plant personnel safety and effluent control and monitoring. The system design also complies with applicable standards of OSHA, EPA, and state and local agencies.

The system filters contaminated gases, and continuously monitoring exhaust gas flow to the atmosphere. HF monitors and alarms are installed upstream of the filtration systems and immediately upstream of the exhaust stack to avoid the release of hazardous materials to the environment. The alarms are monitored in the Separation Plant Control Room.

The TSB GEVS provides for continuous monitoring and periodic sampling of the gaseous effluent in the exhaust stack in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).

Gamma monitors measure the build-up of ^{235}U on prefilters and HEPA filter. Upon detection of high-high gamma levels in the TSB GEVS filter, the TSB GEVS trips.

The unit is located in a dedicated room in the TSB with the GEVS for the Separation Plant. The filters are bag-in/bag-out. The frequency of filter replacement will be determined during the design phase and this section will be revised accordingly.

If the TSB GEVS stops operating, material within the duct will not be released into the building because each of the TSB GEVS connections has a P-trap to catch entrained material that could otherwise fall back into the building from the ductwork during system failure.

The design and in-place testing of the TSB GEVS will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes a potassium carbonate impregnated activated charcoal filter for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address

activated charcoal filters for radioiodine removal are not applicable. The prefilter efficiency (85%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1 (ASME, 1997). The impregnated charcoal filter efficiency (99%) for removal of HF is based on Urenco specifications. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001). Qualification testing, to verify HF removal efficiency, of the impregnated charcoal will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated charcoal filter of charcoal samples will be performed on an annual basis. Throughout the useful life of the impregnated charcoal, 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 charcoal bed for removal of HF.

3.4.9.2.5 Instrumentation

The process variables, pressure, fan speed, and damper positioning are all controlled automatically. The fan speed is automatically controlled to maintain negative pressure in the system. The differential pressure across the filters is monitored and the fan speed is adjusted to maintain the design airflow rates. When a high pressure drop is detected across the filters, an alarm alerts the personnel that a filter change may be necessary. HF monitors measure the concentration of the gas in the air stream. Also, devices are used to measure the level of radiological contamination (alpha only) present in the air stream located in the stack. Deviations from specified values are indicated by alarms. HF and alpha monitors and alarms are installed upstream of the filtration system and immediately upstream of the exhaust stack to avoid 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.

Each area has an alarm that is activated in the event that the TSB GEVS or the fan fails.

The TSB GEVS control system is mounted in a Local Control Center (LCC). This is a stand-alone system that does not generate alarms during normal operation. The LCC provides automatic control of the fan and dampers and provides local control via a Local Operator Interface (LOI) that is mounted in the LCC.

The Central Control System (CCS) has no supervisory control over the TSB GEVS control system. However, the TSB GEVS LCC communicates with the CCS via the dual redundant process network so that comprehensive monitoring of the TSB GEVS status exists. Data that is monitored is fan status, filter and duct pressure measurements, and damper status.

The TSB GEVS LCC has one PLC that provides all automatic control and protection required for the system and also the communication interface to the PCS. All equipment related to the TSB GEVS is directly wired to the LCC.

The radiological activity and HF monitoring instruments are stand-alone and powered separately. These instruments interface with the TSB GEVS LCC via hardwired signals that indicate when alarm limits have been exceeded.

Any shutdown device for the filter train and fan is latched and requires local operator action to reset.

High-level environmental alarms will shut down the TSB GEVS.

3.4.9.2.6 Criticality Safety

Within the TSB Ventilated Room, chemical traps will be emptied and product cylinders may be brought into the room for valve changes and subsequent testing. In the case of the traps there will be a mixture of product, feed and dump traps with a few from the tails operations. The product traps will be 10 kg (22.0 lb) carbon traps with a maximum holdup of 12 kg (26.5 lb) UF_6. The traps will have been de-gassed prior to being removed from the plant and there will be very little of the UF_6 absorbed on the trap that could become airborne. There may be a small amount of carbon drawn into the TSB GEVS as a result of emptying the traps. With approximately 20 carbon traps processed per year it is not considered credible that kilogram quantities of uranium would be drawn into the TSB GEVS, before filters were changed out.

A possible scenario for the acute accumulation of enriched uranium from the Ventilated Room exists from the valve testing operations. For this operation a cylinder is taken into the room and the valve is removed. A new valve is fitted to the cylinder and the cylinder is then pressure tested. This involves pressurizing the container with nitrogen then evacuating. For this operation the cylinder is connected to a portable rig, which in turn exhausts to the TSB GEVS. Since all pumps are lubricated with a UF_6 compatible oil there is the remote possibility that UF_6 could be pumped directly from the cylinder to the TSB GEVS. Weight and temperature trips on the carbon trap in this rig prevent this transfer from occurring.

Within the TSB Decontamination System there are a number of cleaning tanks. Components entering these tanks will have either been cleaned or de-gassed. It is not considered likely that significant quantities of uranium would enter the TSB GEVS as a result of these decontamination operations or the subsequent processing of the residues. The facility also provides the plant with a sample bottle cleaning service. Type 1S sample bottles delivered to the facility will be cleaned provided that there is no more than 20 g (0.04 lb) of residual material within the bottles. Even if this was all UF_6 and the bottle was opened the operator would see white hydrogen fluoride fume and there may be some small quantity of UF_6 associated with the release. Many mal-operations would be required for the TSB GEVS to see the quantity of material that would be needed to initiate a criticality.

Before pumps enter the TSB Contaminated Workshop there is a requirement for them to be de-gassed prior to transfer. It would be unusual for pumps to enter the facility with significant quantities of UF_6 remaining within the pump, including UF_6 dissolved in the Fomblin oil. On entering the facility the pumps are taken to the outgas area where the oil is removed. If dissolved UF_6 were present in the oil then there would be some fuming this would mainly be as a result of the dissolution of the UF_6 from the oil reacting with the water in the air. This would produce UO_2F_2 and HF. The HF would be drawn into the TSB GEVS and the majority of the UO_2F_2 would remain with the oil. The number of product pumps that cannot be successfully de-gassed is small and it is not considered that a significant fraction of the uranium in the oil would enter the TSB GEVS. Once the pumps have been transferred to the hydraulic table there will be uranium associated with the residual oil in the pump and some in the form of dry breakdown products. It is not considered possible that significant quantities of these will become airborne during the cleaning operations.

For the activities in the TSB, the accumulation rate of uranium in the TSB GEVS is very low compared with the safe mass of 12.2 kg U (26.5 lb U) assuming double batching and all the uranium were enriched to 6.0 $^{w}/_{o}$. These low accumulations coupled with regular sampling of filters, the weight trips and temperature trips, render a criticality accident highly unlikely.

3.4.10 Centrifuge Test and Centrifuge Post Mortem Processes

This section describes the basic components, functional requirements, and utilities required for operation of the Centrifuge Test Facility (CTF) and Centrifuge Post Mortem Facility (CPMF). The CTF and CPMF are located in the Centrifuge Assembly Building (CAB) as shown in Figure 3.3-13, Centrifuge Assembly Building, First Floor. These two facilities are segregated within the CAB for two reasons; the presence of uranium hexafluoride results in the areas being classified as process areas and the sensitive operations undertaken within the facilities require personnel access control. The functional requirements for the Centrifuge Test Facility and the Centrifuge Post Mortem Facility are presented in Table 3.4-17, Functional Requirements for Centrifuge Test and Post Mortem Facilities. Utility requirements for the two facilities are presented in Table 3.4-18, Utility Requirements for Centrifuge Test and Post Mortem Facilities.

3.4.10.1 Centrifuge Test Facility

3.4.10.1.1 Functional Description

The principal functions of the Centrifuge Test Facility (CTF) are to provide a means of functionally testing the performance of production centrifuges to ensure compliance with design parameters and to investigate production and operational problems. The facility consists of two test positions.

Testing in the CTF is performed by feeding a stream of gaseous UF_6 into the centrifuge and removing enriched and depleted streams, Product and Tails, respectively. During this process, the centrifuge is maintained at the required operating frequency, temperature, and pressure, and samples are taken from the Product and Tails streams to enable determination of the separative capacity of the centrifuge under test.

The discharge line from the mobile vacuum pump set and flexible exhaust hose is provided to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System, see Section 3.4.10.3.

3.4.10.1.2 Major Components

The equipment located in the CTF comprises the following main components or sub-systems.

A. Centrifuge Cubicles

B. Centrifuge Inverter

C. Cooling Water System

D. UF_6 Feed and Take-off System

E. Chemical Trap and Vacuum Pump Sets

F. Supervisory Control and Data Acquisition System (SCADA)

G. Uninterruptible Power Supply (UPS)

H. Centrifuge Crash Detection System.

I. SCADA System.

J. Uninterruptible Power System (UPS).

K. Centrifuge Crash Detection System.

3.4.10.1.3 System Description

A. Centrifuge Cubicles.

The Centrifuge Cubicle consists of an insulated box manufactured from non-flammable insulating material. Each cubicle has front and top opening doors to facilitate access for loading and making process and utility connections.

A specially designed centrifuge mounting base plate and stand provides a solid mounting and attachment to the floor.

The test centrifuge is transported to a location immediately adjacent to the cubicle on a transport trolley. The centrifuge is then loaded into the cubicle using a jib crane with an electrically powered hoist. A platform is provided to make the process pipe work connections at the top of the centrifuge.

Air within the cubicle is maintained at a nominal operating set point, which is adjustable using an electrical heater located near the bottom of the cubicle, in conjunction with a circulating fan.

Cooling water is supplied through the wall of the Centrifuge Cubicle to the test centrifuge and subsequently returned to a local, dedicated Cooling Water System.

A flexible exhaust hose connected to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is positioned close to the centrifuge flange to provide local exhaust in the working area during disconnection from the facility. Appropriate gloves and positive pressure face mask with appropriate filtration is used during disconnection of any UF_6 process connections.

B. Centrifuge Inverter.

Each test position is provided with a variable speed inverter. The inverter provides a drive signal to the centrifuge motor. Drive up and drive down sequences are controlled by the SCADA system.

C. Cooling Water System.

The cooling water system is composed of a proprietary stand-alone unit. Heating and chilling capacity is required to enable delivery of a stable flow of water to both test positions. Supply and return connections are made to the test centrifuges mounted in the Centrifuge Cubicles.

D. UF_6 Feed and Take-off System.

The feed and take-off system consists of two identical stainless steel vessels; the UF_6 capacity of the system is 50 kg (110 lb).

Each vessel is fitted with cooling coils which carry liquid nitrogen to maintain the temperature at –70°C (-94°F) when used in take-off mode and heat tracing which maintains the temperature at

20°C (68°F) when used in feed mode. The neck of each vessel has heat tracing that is set to 25°C (77°F), irrespective of feed or take-off mode, preventing UF_6 desublimation in the inlet and outlet.

E. UF_6 Feed Supply.

Gaseous UF_6 is generated by a process of sublimation from one of the vessels, nominated the feed vessel. Energy required for sublimation is supplied by electrical heat tracing controlled to 20°C (68°F).

The feed is delivered from the feed vessel to the centrifuge, via a system of control valves and orifice plates, to achieve the required centrifuge feed pressure and flow rate.

F. UF_6 Take-off.

The enriched and depleted UF_6 streams are drawn from the centrifuge. Each stream is passed through an automatic control valve and orifice plate for flow measurement purposes. The streams are then merged and desublimed in the second vessel, nominated the take-off vessel. This vessel is chilled to –70°C (-94°F) using liquid nitrogen.

The piping/valve configuration allows each take-off stream to be diverted along an alternative route to allow a dedicated sample to be taken. A flexible tube connected to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is positioned close to the sample bottle during sample bottle connection and disconnection to provide local exhaust of the working area.

When all the UF_6 has been transferred to the take-off vessel, the previously heated feed vessel is cooled, and the previously cooled take-off vessel is heated, becoming the feed vessel, and allowing the UF_6 to be fed in the opposite direction.

The UF_6 can be recycled in this manner for approximately one year. A flexible tube connected to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is positioned close to the vessel during replacement of the UF_6 inventory to provide local exhaust of the working area.

G. CTF Feed and Take-off Vessel Recharging.

As stated previously, after approximately one year's operation it is necessary to replenish the system charge of about 50 kg (110 lb) UF_6.

This is affected by initially transferring the full UF_6 inventory into a single vessel. After this has been completed, the vessels are isolated and allowed to return to ambient temperature.

The process pipe work is evacuated and purged with nitrogen gas several times in a cyclic manner. Operational experience has shown that this procedure minimizes the possibility of UF_6 or HF release.

A flexible exhaust hose connected to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is positioned adjacent to the flange connection of the vessel isolation valve to provide local exhaust of the working area. The flange connection is then broken and blank flanges are fitted to the isolation valve and the facility process pipe work.

The vessel is emptied to an off-line UBC in the separation plant. The vessel is recharged from a feed cylinder and subsequently refitted to the centrifuge test facility.

H. Chemical Traps and Vacuum Pump Set.

The chemical traps and vacuum pump set are composed of a stainless steel trap filled with 10 kg (22.1 lb) of activated carbon, a stainless steel trap filled with 15 kg (33.1 lb) of aluminum oxide and a two stage rotary vane vacuum pump fitted with an nitrogen purge. The carbon trap of the chemical traps and vacuum pump set has a weighing system that will automatically trip the associated vacuum pump on high carbon trip weight.

The vacuum pump has upstream and downstream filters to prevent oil migration and discharges to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System. These items are located on a movable skid.

The chemical traps and vacuum pump set provides the following functionality:

1. Initial evacuation of the test centrifuge.
2. Removal of UF_6 from the centrifuge and connecting pipe work during testing in the event the normal take-off route becomes unavailable.
3. Removal of non-condensable gases, which accumulate in the chilled take-off vessel during testing.
4. System purging at the end of testing; the centrifuge is evacuated and purged several times with nitrogen gas through a control valve which limits the rate of pressure change.

I. SCADA System

The centrifuge test facility has a dedicated control and data acquisition system. Control functions are performed using a Programmable Logic Controller (PLC). Independent hard wired trips are used for safety related functions.

The operator interfaces with the SCADA system via a computer terminal. The operator interface displays real time values and trends of all instruments associated with the centrifuge test facility and allows selection of various process modes and initiation of sequences.

J. Uninterruptible Power System (UPS).

A UPS is required to provide backup power to the PLC, the operator interface, and the hardwired safety circuits.

K. Centrifuge Crash Detection System.

Each test position is fitted with a centrifuge Crash Detection System. This system consists of a shock sensor, that is strapped to the test centrifuge, and signal processing electronics. The signal processor provides a digital input to the SCADA system PLC that, in turn, initiates a system shutdown and provides an alarm signal.

3.4.10.1.4 Design and Safety Features

As stated previously, control of the Centrifuge Test Facility is undertaken via the SCADA system. All process states and sequences are initiated by the operator. The operator can override any sequence and take manual control of the facility.

There are few hazards associated with the facility. The principal hazards are centrifuge failure or heat tracing failure of the feed vessel resulting in overheating of the vessel.

The safety enclosure for the centrifuge containment is well established and underpinned with experimental evidence.

In the event of an electrical heating or heat trace control failure, the design is such that with continuous maximum power input to the heating elements, no damage to the equipment can occur.

The electrical heating and heat tracing circuits of the UF_6 feed and take-off vessels are each fitted with two resistance temperature devices (RTDs). One RTD is used for control. The second RTD provides an independent fail-safe, hardwired trip of the heat tracing, set at 35°C (95°F). An independent capillary temperature sensor for automatic, fail safe, high temperature trip of the heat tracing is also provided. This value has been selected to prevent the formation of UF_6 gas at above atmospheric pressure.

The power to these electrical circuits is also removed if the pressure at the UF_6 feed or take-off vessel exit rises above 120 mbar (1.74 psia).

3.4.10.2 Centrifuge Post Mortem Facility

3.4.10.2.1 Functional Description

The principal functions of the Centrifuge Post Mortem Facility (CPMF) are as follows:

A. Facilitate dismantling of contaminated centrifuges using equipment and processes that minimize the potential to contaminate personnel or adjacent facilities.

B. Collect potentially contaminated components for transfer to the Solid Waste Collection Room in the TSB prior to disposal.

Operational experience to-date has shown that the demand for centrifuge post mortems is infrequent.

Centrifuges are brought into the CPMF from the cascade hall on a specially designed transport cart. The CPMF is used for careful, diligent dismantling of centrifuges. The centrifuges will have been operating in UF_6 and are therefore contaminated. The facility is equipped with radiological monitoring devices (alpha in air), toilets and washing facilities, and hand, foot, and clothing personnel monitors to detect surface contamination. Wash water is collected and monitored for contamination prior to discharge. All ventilation exhausts are routed through the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System. Flexible exhaust hoses, that are connected to the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System, are positioned by the operator local to the centrifuge prior to commencing the dismantling process.

Atmospheric conditions within these two facilities require control. To facilitate this requirement, an airlock entry is employed. For additional functional and utility requirements see Table 3.4-17, Functional Requirements for Centrifuge Test and Post Mortem Facilities, and Table 3.4-18, Utility Requirements for Centrifuge Test and Post Mortem Facilities.

3.4.10.2.2 Major Components

The equipment located in the Centrifuge Post Mortem Facility consist of the following main components or sub-systems:

A. Centrifuge dismantling facility

B. Centrifuge manipulation equipment

C. Inspection facilities

D. Solid and liquid waste collection and segregation facilities.

3.4.10.2.3 System Description

A. CPMF Centrifuge Dismantling Facility.

The centrifuge dismantling facility is composed of a stand, onto which the centrifuge is mounted, a local jib crane, and miscellaneous tools.

The stand has an elevated working platform to allow access to the top of the centrifuge. The platform is large enough to accommodate two people, necessary tools to enable dismantling, and a lay down area for potentially contaminated components.

A jib crane is located over the stand to enable centrifuge removal from and replacement to the transport cart, and to facilitate loading and unloading the stand.

Miscellaneous tools are used to dismantle the centrifuge. These tools are solely for the purpose of centrifuge post mortem and are stored adjacent to the dismantling facility.

A flexible exhaust hose from the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is positioned adjacent to the centrifuge enclosure to provide local exhaust in the working area during dismantling.

The dismantling facility has to deal with both intact and crashed centrifuges. The dismantling processes are consequently different.

Dismantling of intact centrifuges is relatively easy. Removal of the internals is facilitated by use of the jib crane.

Crashed centrifuges, however, yield fragmented debris. To contain the spread of potentially contaminated debris, a dedicated vacuum cleaner is used to capture particulates. The dedicated vacuum cleaner complies with the requirement to be safe by shape to prevent the possibility of criticality. Removal of the internals often requires inversion of the centrifuge casing to retrieve component parts for subsequent inspection. This operation is undertaken using the centrifuge manipulation equipment.

Operational restrictions are placed on personnel undertaking post mortem activities. These are summarized as follows:

All personnel must utilize personal protection equipment that is identified via a risk assessment and follow operational procedures to undertake post mortem activities.

To minimize potential for criticality, only one centrifuge at a time can be dismantled within the facility. Aqueous and non-aqueous cleaning agents are not allowed in the centrifuge post mortem facility. Component cleaning can only be carried out using dry wipe techniques.

B. Centrifuge Manipulation Equipment.

The centrifuge manipulation equipment is a piece of mechanical handling equipment that provides for rotation of the centrifuge casing.

C. Inspection Facilities.

An inspection area is located within the centrifuge post mortem facility to facilitate collection of evidence to support failure hypotheses. The inspection facilities have an inspection bench, portable lighting, a microscope, an endoscope, and a digital video camera.

D. Solid and Liquid Waste Collection and Segregation Facilities.

Waste from centrifuge post mortem consists of small quantities of both non-aqueous liquid and dry solids.

The non-aqueous liquid waste is transferred into a 5 L (1.32 gal) plastic container. This container is stored in the centrifuge post mortem facility until it is full. The full container is subsequently transferred to the Solid Waste Collection Room in the TSB. It is then characterized, packaged, and sent for disposal.

The solid wastes are segregated into like materials prior to disposal. Some of the items are required to be broken down to reduce volume and ease handling. This is carried out using a mechanical bench saw. Wastes are then bagged and monitored to determine the level of surface contamination. The containerized wastes are sent to the Solid Waste Collection Room in the TSB for disposal.

3.4.10.2.4 Design and Safety Features

Historical 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 is generated. Operational experience in Europe has shown that uranium is found as surface contamination in the form of either UO_2F_2 or uranium tetrafluoride (UF_4).

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 contaminants from the Centrifuge Test and Post Mortem Facilities. The system also ensures the Centrifuge Post Mortem Facility is maintained at a negative pressure with respect to adjacent areas. The system is shown on Figure 3.4-19, 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 total airflow to be handled by the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is 9,345 m^3/hr (5,500 cfm). Flow rates and capacities are preliminary and are subject to change during final design.

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 consists of the following major components.

- Duct system
- Prefilter
- Impregnated carbon filter (impregnated with potassium carbonate)
- High Efficiency Particulate Air Filter (HEPA)
- Two exhaust filtration fans
- Exhaust stack
- Stack alpha monitor
- Stack HF monitor.

3.4.10.3.3 Design Description

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System consists of a duct network that serves the Centrifuge Test and Post Mortem Facilities and operates at negative pressure. The ductwork is connected to one filter station and vents through either of two 100% fans. Both the filter station and either of the fans can handle 100% of the effluent. One of the fans will normally be in standby. Operations that require the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System to be operational are manually shut down if the system shuts down. The system capacity is estimated to be 9,345 m^3/hr (5,500 cfm).

Gases from the associated areas pass through the 85% efficient prefilter which removes dust and protects the carbon filter, then through the 99% efficient activated carbon (potassium carbonate impregnated) filter that captures HF. Remaining uranic particles (mainly UO_2F_2 particles) will be filtered by the 99.97% efficient HEPA filter. The remaining clean gases pass through a fan, which maintains the negative pressure upstream of the filter station. The clean gases are then discharged through the stack on the Centrifuge Assembly Building.

A minimum velocity is maintained in the duct system in order to ensure that particulate contaminates are conveyed through the ductwork without settling. Each section also has a damper to balance the individual flows in the system. Flexible exhaust hoses are provided in both the Centrifuge Test Facility and the Centrifuge Post Mortem Facility. A hood is also provided in the Centrifuge Post Mortem Facility.

The materials of construction, corrosion allowances, and fabrication specifications for the equipment and ductwork used in the GEVS are compatible with UF_6 and HF and are noncombustible.

3.4.10.3.4 Design and Safety Features

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is designed to protect plant personnel against uranium and HF exposure.

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System is designed to meet all applicable NRC requirements for public and plant personnel safety and effluent control and monitoring. The system design also complies with applicable standards of OSHA, EPA, and state and local agencies.

The Centrifuge Test and Post Mortem Facilities Exhaust Filtration System provides for continuous monitoring and periodic sampling of the gaseous effluent in the exhaust stack in accordance with the guidance in Regulatory Guide 4.16 (NRC, 1985).

The system filters contaminated gases, and continuously monitoring exhaust gas flow to the atmosphere. The system also provides primary confinement for the Centrifuge Post Mortem Facility by maintaining the Centrifuge Post Mortem Facility at a negative pressure relative to adjacent areas. An HF monitor and associated alarm and an alpha radiation monitor and associated alarm are installed immediately upstream of the exhaust stack to avoid the release of hazardous materials to the environment. The frequency of filter replacement will be determined during the design phase and this section will be revised accordingly.

The design and in-place testing of the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System will be consistent with the applicable guidance in Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989). The system includes a potassium carbonate impregnated activated charcoal filter for HF removal. As such, the portions of Regulatory Guide 1.140 (NRC, 2001), ASME AG-1-1997 (ASME, 1997), and ASME N510-1989 (ASME, 1989), which address activated charcoal filters for radioiodine removal are not applicable. The prefilter efficiency (85%) is based on testing in accordance with ASME AG-1-1997 (ASME, 1997). The HEPA filter efficiency (99.97%) is based on removal of 0.3 micron particles when tested in accordance with ASME-AG-1 (ASME, 1997). The impregnated charcoal filter efficiency (99%) for removal of HF is based on Urenco specifications. In-place testing and inspections of the filters will be performed in accordance with the guidance in Regulatory Guidance 1.140 (NRC, 2001). The frequency for performance of in-place filter testing and the acceptance criteria for penetration and leakage (or bypass) will be consistent with the guidance in Regulatory Guide 1.140 (NRC, 2001). Qualification testing, to verify HF removal efficiency, of the impregnated charcoal will be performed using ASTM D6646-03 (ASTM, 2003), modified to reflect removal of HF instead of hydrogen sulfide. Laboratory testing of the impregnated charcoal filter of charcoal samples will be performed on an annual basis. Throughout the useful life of the impregnated charcoal, 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 charcoal bed for removal of HF.

3.4.10.3.5 Instrumentation

The process variables, pressure, fan speed, and damper positioning are all controlled automatically. The fan speed is automatically controlled to maintain negative pressure in the system. The differential pressure across the filters is monitored to provide indication of when filter replacement is required. An HF monitor measures the concentration of the gas in the air stream. Also, a radiation detector is used to measure the level of radiological contamination (alpha only) present in the air stream located in the stack. Deviations from specified values for HF and alpha radiation are indicated by alarms. The HF and alpha radiation monitoring devices have non-interruptible power supplies in order to continue to function during a general power failure.

3.4.11 Material Handling Processes

The NRC staff previously reviewed the Claiborne Enrichment Center SAR application relative to the Material Handling Processes and concluded that the descriptions, specifications or analyses provided an adequate basis for safety review of the facility operations and that the construction and operation of the facility would not pose an undue risk to public health and safety. The specific discussion on the Material Handling Processes is provided in NUREG-1491 (NRC, 1994), Sections 3.1 and 3.2.

The NRC in Bulletin 2003-03 (NRC, 2003), Potentially Defective 1-in valves for Uranium Hexafluoride Cylinders, identified performance and safety concerns with 1-in valves for UF_6 cylinders manufactured by the Hunt Valve Company. In response to Bulletin 2003-03 (NRC, 2003), LES will not purchase UF_6 cylinders with the 1-in Hunt valves installed nor purchase any replacement 1-in valves from Hunt.

In the unlikely event that any cylinders are received at the NEF with the 1-in Hunt valves installed, the following actions will be taken.

- If the cylinder is empty, the valve will be replaced before the cylinder is used in the facility.
- If the cylinder is filled, a safety justification to support continued use of the cylinder until the valve can be replaced will be developed or the valve will be replaced in accordance with NEF procedures.

No cylinders with the 1-in Hunt valve installed will be used as UBCs.

3.4.11.1 Cylinder Receipt and Shipping

The Cylinder Receipt and Dispatch Building (CRDB) provides for handling of feed cylinders, product cylinders, semi-finished product cylinders, prepared empty cylinders and UBCs, and provides space for the following services:

- Cylinder loading and unloading
- Inventory weighing
- Secure internal storage (no UBC or empty feed storage in CRDB)

- Preparation and storage area for overpack/protective structural packaging.

The cylinders are received, shipped offsite, stored, and transferred to and from the UF_6 Handling Areas, Blending and Liquid Sampling Area, and UBC Storage Pad.

Prepared empty cylinders, semi-finished product cylinders, full feed cylinders, and final product cylinders are stored in the CRDB.

Full UBCs and empty feed cylinders are not stored in the CRDB. They are transported through the TSB and stored in the UBC Storage Pad.

The CRDB layout is shown on Figure 3.3-10, Cylinder Receipt and Dispatch Building, First Floor, Part A, and Figure 3.3-11, Cylinder Receipt and Dispatch Building, First Floor, Part B. The UF_6 Feed cylinder delivery and storage requirements are presented in Table 3.4-19, UF_6 Feed Cylinder Delivery and Storage Requirements.

3.4.11.1.1 Description

The majority of the floor area in the CRDB is used as a storage or staging area for feed and product cylinders. The cylinders are placed on concrete saddles to stabilize them while they are stored in this area. Different size saddles are provided for 48-in and 30-in cylinders. The cylinders are positioned such that access is possible from an overhead crane.

Trucks arrive at the building carrying feed cylinders, empty UBC or product cylinders, and enter through the main vehicle loading bay. This bay is equipped with vehicle access platforms that aid with cylinder loading and unloading operations.

Unloaded trucks either leave the site or remain in a staging area adjacent to the CRDB. Trucks in this staging area await cylinders that are to be shipped from the site.

3.4.11.1.2 Equipment

The following equipment is used for cylinder handling in the CRDB.

A. Vehicle Loading And Unloading Platform.

The vehicle loading and unloading platforms are located adjacent to the main transport vehicle access doorways. These platforms provide a safe method of transfer to the vehicle trailer while loading and unloading activities are in progress. Cylinders will be stored a minimum of one meter from the vehicle platform to eliminate the fire hazard associated with trucks in the CRDB.

B. Double Girder Bridge Cranes.

Two double girder bridge cranes handle the cylinders in the CRDB. The cranes span half the width and run the full length of the main storage building. They are operated by an automated control system and equipped with remotely operated grabs. Each hoist has a maximum lift of 9 m (29.5 ft). Crane movement requirements are presented in Table 3.4-20, Crane Movement Requirements. The minimum lift is based upon the following data:

- Floor to top height of a vehicle mounted ISO container — 4.1 m (13.4 ft)
- Lift clearance between ISO container and underside of cylinder — 0.6 m (2 ft)
- Allowance for a 48 in cylinder — 1.2 m (3.9 ft)

- Typical length of a universal cylinder grab (including fixing) 2.0 m (6.6 ft)
- Allowance for unknown effect of a 48-in cylinder overpack 1.0 m (3.25 ft)
- Total 8.9 m (29.16 ft)

The crane specifications are as follows:

• Span	20 m	(65.6 ft)
• Capacity	20 MT	(44,100 lb)
• Hoist lift height	9 m	(29.5 ft)
• Hoist lift speed (Variable Frequency Drive (VFD))	6 m/min	(20 ft/min)
• Travel length	225 m	(708.67 ft)
• Bridge travel speed (VFD)	49 m/min	(161 ft/min)
• Brake type	Direct Current Disc	

ISO containers are International Organization for Standardization Series 1 freight containers that are supplied in accordance with the ISO 668:1995 (ISO, 1995) Standard. These containers are used for intercontinental shipping. They are 2,438 mm (8 ft) wide and are available in a variety of heights ranging from 2,438 mm (8 ft) to 2,896 mm (9.5 ft).

C. Scales.

Each cylinder that enters or exits the CRDB is weighed. Weigh scales capable of weighing a load of 17 MT (37,500 lb) and capable of accepting a load of 20 MT (44,100 lb) are required on each end of the CRDB. One set of scales is utilized in the area adjacent to the cylinder truck loading/unloading bay. The other set of scales is located in the area adjoining the Blending and Liquid Sampling Area. The scales are capable of weighing to a tolerance of ±2.5 kg (±5.5 lb). The scales have a reader and printout facilities, and are located in a pit such that the weigh table is flush with the finished building floor slab.

D. Flatbed Trucks And Rail Transporters.

After processing, the cylinders are transported between the CRDB, the UF_6 Handling Areas, and the UBC Storage Pad via flatbed trucks. A double girder Gantry crane is used to manage the cylinders in the UBC Storage Pad.

3.4.11.1.3 Cylinder Specifications

Cylinders stored and handled in the CRDB vary in size and weight from 30B cylinders to 48Y cylinders. The cylinders have the following characteristics:

30B Cylinder		
Weight of UF_6	2,277 kg	(5,020 lbs)
Gross cylinder weight	2,912 kg	(6,420 lbs)
Diameter	762 mm	(2.5 ft)
Length	2,070 mm	(6.8 ft)

48Y Cylinder		
Weight of UF_6	12,501 kg	(27,560 lbs)
Gross cylinder weight	14,860 kg	(32,761 lbs)
Diameter	1,232 mm	(4.08 ft)
Length	3,728 mm	(12.25 ft)

48X Cylinder		
Weight of UF_6	9,539 kg	(21,030 lbs)
Gross cylinder weight	11,580 kg	(25,530 lbs)
Diameter	1,220 mm	(4 ft)
Length	3,020 mm	(9.9 ft)

3.4.11.1.4 CRDB Storage Areas

The CRDB accommodates the following areas:

Final product storage	330 m^2	(3,552 ft^2)
Overpack storage (72 overpacks)	440m^2	(4,736 ft^2)

3.4.11.1.5 Product Cylinder Storage

Semi-finished product cylinder storage areas are shown on Figure 3.3-10, Cylinder Receipt and Dispatch Building, First Floor, Part A, and final product storage areas are shown on Figure 3.3-11, Cylinder Receipt and Dispatch Building, First Floor, Part B. The areas accommodate 125 semi-finished cylinders and 125 final product cylinders.

Site vehicle access/single loading bay	400 m^2	(4,306 ft^2)
Full feed cylinder storage	6,231 m^2	(67,070 ft^2)
Prepared (empty) cylinder storage	400 m^2	(4,306 ft^2)
Semi-finished product storage	330 m^2	(3,552 ft^2)
Preparation Area	400 m^2	(4,306 ft^2)

3.4.11.1.6 Feed Cylinder Storage

Feed cylinder storage areas are shown on Figure 3.3-10 and on Figure 3.3-11. Feed material is stored under vacuum in corrosion resistant Type 48Y or 48X cylinders. The CRDB provides enough space to store up to 708 cylinders. These cylinders can be stored without providing room for cylinder maintenance because they are only in temporary storage. Based on this type of design, the area allocated per feed cylinder is 8 m^2 (86 ft^2). Thus, the maximum storage area required is 5664 m^2 (60,967 ft^2). A 10% allowance is reserved for staging purposes, bringing the total required area to 6,231 m^2 (67,070 ft^2).

3.4.11.1.7 Cylinder Deliveries

Cylinder deliveries to and from the site generally consist of feed deliveries to the site, product transport from the site, and return of supplier empty feed cylinders. At the NEF, full 48X cylinders are delivered one cylinder per delivery vehicle. Full 48X cylinders may be delivered two cylinders per delivery vehicle. New empty 48-in cylinders are delivered nine cylinders per delivery vehicle. Empty washed out 48-in cylinders are delivered six cylinders per vehicle. The

30-in product cylinders are delivered four cylinders per 6 m (20 ft) of delivery vehicle. The number of product cylinders per vehicle can vary and a typical shipment frequency would be one vehicle per 3 days (122 shipments per year). This information for a total plant capacity of 3 million SWU per year is summarized below. The figures in the following table represent a maximum number of deliveries per year. An alternate cylinder management strategy whereby empty feed cylinders are refilled with tails and new empty 48Y cylinders are provided to the feed suppliers would reduce the number of NEF deliveries.

Delivery Description	Number cylinders per year	Number cylinders per vehicle	Number deliveries per year
Feed In	690	1	690
Empty Tails In	625	9	70
Product Out	350	4	88
Empty Feed Out	690	6	115
Total	-	-	963

3.4.11.2 Cylinder Transport within the Facility

3.4.11.2.1 Cylinder Transport Between CRDB and the Product Blending and Liquid Sampling Area

Two double girder bridge cranes in the CRDB are used to move cylinders to either of the two weighing stations at the end of the CRDB. Cylinders moving from the CRDB to the Blending and Liquid Sampling Area and vise versa may be weighed. Each of the weighing stations has a transporter to convey the cylinders from the CRDB to the Blending and Liquid Sampling Area. The transporters travel along rails embedded in the floor. At rail intersections, physical stops prevent the CRDB transporter from colliding with the UF_6 Handling Area transporter. The rail system is depicted on Figure 3.3-10, Cylinder Receipt and Dispatch Building, First Floor, Part A.

A total of two rail transporters for the CRDB to UF_6 Handling/Blending and Liquid Sampling are included in the facility. The transporters may be battery powered, or fed by an electric feeder.

Cylinders are empty product, product, empty feed, feed, empty UBCs, UBCs, or semi-finished product cylinders.

3.4.11.2.2 Cylinder Transport Between the Product Blending and Liquid Sampling Area and the TSB

Cylinders are transported between the Blending and Liquid Sampling/ UF_6 Handling transporter and the TSB by a rail transport device that travels along rails embedded in the floor. Once the cylinders are in the TSB, they are lifted and moved with a bridge crane hoist system located in the Cylinder Preparation Room.

One rail transporter between the UF_6 Handling/Blending and Liquid Sampling and the TSB is installed in the facility. The transporter may be battery powered, or fed by an electric feeder.

New or clean cylinders are empty product, empty feed or empty tails. See Section 3.3.1.2.2.5 for details of cylinder preparation.

3.4.11.2.3 Cylinder Testing

When cylinders are delivered without valves and plugs, an internal inspection of the washed out or new cylinders is made in the Cylinder Preparation Room using a conventional remote optical viewing device, called an Endoscope. 48-in cylinders that are supplied with fitted valves and plugs do not require testing. All 30-in cylinders are inspected internally for criticality safety purposes.

Cylinders are pressure tested using compressed air in accordance with ANSI N14-2001 (ANSI, 2001). This system is used for testing new and decontaminated empty cylinders only. The test procedure is automated and is performed after the valve and plug fitting activities have been completed. The pressure test is administered via a set of program controlled automatic valves.

3.4.11.2.4 Cylinder Transport Between the Product Blending and Liquid Sampling Area and the UF_6 Handling Areas

A rail system extends between the Blending and Liquid Sampling Area and all of the UF_6 Handling Areas. The rail has two independent rail transporters. Each of the transporters has a drawbridge that links the transporter to the appropriate station or adjoining transporter. The UF_6 rail transporters are depicted in Figure 3.4-20, Rail Transporter Area Equipment Drawing. Its function is the transfer of cylinders to the appropriate Product Blending System Donor Station, Product Blending System Receiver Station, Product Liquid Sampling Autoclave, Solid Feed Station, Product Low Temperature Take-off Station, Tails Low Temperature Take-off Station or Feed Purification Low Temperature Take-off Station.

Cylinders are empty product, product, empty feed, feed, empty UBCs, UBCs or semi-finished product cylinders. Each of the transporters may be battery powered or fed by an electric feeder embedded in the concrete.

3.4.11.3 UBC Storage Pad

The NEF utilizes an area outside of the Cylinder Receipt and Dispatch Building (CRDB) for storage of UBCs. The UBC Storage Pad is used for storage of cylinders containing UF_6 that is depleted in ^{235}U. It is also used for the storage of empty feed cylinders. Access to the cylinder storage pad is controlled and a fence is provided so that only authorized vehicles may enter the area. The tails storage requirements are presented in Table 3.4-21, UBC Storage System Requirements.

3.4.11.3.1 Description

Space is allocated to provide storage of UBCs for 30 years of output from the facility. The uranium byproduct material is stored under vacuum in corrosion resistant Type 48Y cylinders. Empty feed cylinders are also Type 48Y cylinders.

The UBC Storage pad can accommodate storage of up to 15,727 48Y cylinders. The cylinders are stacked two high. Concrete saddles are used to store the cylinders approximately 200 mm (8 in) above ground level.

3.4.11.3.2 Equipment

The UBC Storage Pad layout is based on moving the cylinders with cranes and either diesel or electric flatbed trucks. Two double girder bridge cranes are used to load the depleted UF_6 cylinders onto the flatbed trucks in the CRDB. The trucks transport the cylinders from the CRDB to the double girder Gantry crane in the UBC Storage Pad. The Gantry crane is used to remove the cylinders from the flatbed trucks and place them on the UBC Storage Pad. The Gantry crane is designed to double stack the cylinders.

The specifications for the double girder Gantry crane are as follows:

Span	43.6 m (143 ft)
Capacity	20 MT (44,100 lb)
Hoist lift height (maximum)	9 m (30 ft)
Hoist lift speed (VFD)	6 m/min (20 ft/min)
Travel length	641 m (2,100 ft)
Bridge travel speed (VFD)	49 m/min (160 ft/min)
Trolley travel speed (VFD)	24 m/min (80 ft/min)
Brake type	Direct Current Disc

3.4.11.3.3 UBC Storage

The selected storage option is a double-stacked cylinder storage using a Gantry crane and flatbed trucks for cylinder handling. This type of storage arrangement facilitates visual inspection and removal of the cylinders for maintenance.

The total area for UBC storage for facility operation is approximately 8.5 ha (21 acres). These areas include a 10% allowance for staging activities, but do not include allocated areas for access or perimeter roads.

3.4.11.3.4 Empty Feed Cylinder Storage

Empty feed cylinders require a radiological cooling period in storage prior to return to the customer. The cooling period is dependent upon the emitted dose, and is typically three months. No additional spacing is required for gamma reading purposes. The area allocated per empty feed cylinder is 8 m^2 (86 ft^2). An allowance has been made for six months of storage of empty feed cylinders. This requires a space large enough to accommodate 354 cylinders, a total of 2832 m^2 (30,483 ft^2). With the 10% allowance for staging purposes, a total area of 3,115 m^2 (33,530 ft^2) is required. The area allocated for empty feed cylinders is located in the UBC Storage Pad.

3.4.12 References

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TABLES

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Table 3.4-1 UF_6 Feed System Design Basis
Page 1 of 4

Equipment Requirements			
Component	Quantity Per		
	Cascade Hall	Separations Building Module	Plant Total
Solid Feed Station and Associated Valve Hot Box	6	12	36
Feed Purification Low Temperature Take-off Station and Associated Valve Hot Box	2	4	12
Feed Purification UF_6 Cold Trap	2	4	12
Feed Purification Vacuum Pump/ Chemical Trap Set	2	4	12

Flow	Per Cascade Hall	Number Cascades
Continuous Minimum – kg/hr (lb/hr)	13.5 (29.8)	1
Continuous Maximum – kg/hr (lb/hr)	187 (412)	8

Solid Feed Station	
Number per Cascade Hall	6
On-line	3
Standby or Preparation	2
Spare (Standby, Prep, Maintenance)	1
Cylinder Type	48 X or 48Y
Capacity UF_6, kg (lb)	9,539 or 12,501 (21,033 or 27,565)
Heating Requirements	Air, via dedicated heater
Temperature, °C (°F)	61 (142)

Table 3.4-1 UF_6 Feed System Design Basis
Page 2 of 4

Solid Feed Station Weighing System	
Type	Load Cell
Capacity, kg (lb)	16,000 (35,300)

Feed Purification Low Temperature Take-off Station	
Number per Cascade Hall	2
Available, On-line	1
Spare (Standby, Prep, Maintenance)	1
Cylinder Type	48 X or 48Y
Capacity UF_6, kg (lb)	9,539 or 12,501 (21,033 or 27,565)
Cooling	
Medium	Air, via dedicated chiller
Temperature, °C (°F)	-25 (-13)
Heating	
Heating Requirements	Cylinder Valve Hot Air Blower
Temperature, °C (°F)	63 (145)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	16,000 (35,300)

Table 3.4-1 UF_6 Feed System Design Basis
Page 3 of 4

Feed Purification UF_6 Cold Trap	
Number per Cascade Hall	2
Available, On-line	1
Spare (Standby, Prep, Maintenance)	1
Capacity, kg (lb) UF_6	50 (110)
Cool Down / Desubliming	
Operating Temperature, °C (°F)	-60 (-76)
Heat Up / Subliming	
Operating Temperature, °C (°F)	20 (68)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	To be determined at final design.

Feed Purification Vacuum Pump/Chemical Trap Set				
Number per Cascade Hall	2			
Available, On-line	1			
Spare (Standby, Prep, Maintenance)	1			
Vacuum Pump				
Capacity, m^3/hr (gpm)	40 (176)			
Chemical Traps (Note 1)				
Type	Chemical	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	HF Removal	Oil Removal	Oil Removal
Count	One	One	One	One
Media	Activated Carbon	Aluminum Oxide (Al_2O_3)	Al_2O_3	Activated Carbon

Note 1: Each Vacuum Pump/Chemical Trap Set has the above chemical traps.

Table 3.4-1 UF_6 Feed System Design Basis
Page 4 of 4

Hot Boxes, Pipe Heat Tracing	
Media	Electric
Temperature, °C (°F)	56 to 64 (133 to 147)

Nitrogen Purge	
Operating Pressure, mbar (psia)	<1,000 (14.5)
Gas Usage	Intermittent flow in small quantities.

Table 3.4-2 UF_6 Feed System Codes and Standards

Page 1 of 1

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the UF_6 Feed System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the UF_6 Feed System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 material handling equipment in the UF_6 Feed System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the UF_6 Feed System.
All process piping in the UF_6 Feed System shall meet or exceed the requirements of the American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail design.
All 48-in cylinders used in the UF_6 Feed System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.4-3 Cascade System Codes and Standards

Page 1 of 1

The Centrifuge Machine Passive Isolation Devices is designed, constructed, tested, and maintained to QA Level 1.
Rotating equipment is designed in accordance with the appropriate industry codes and standards.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards.
All process piping in the Cascade System shall meet or exceed the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail engineering.
The design of electrical systems and components in the Cascade System is in conformance with the requirements of the National Electrical Safety Code, IEEE C2, current edition in effect at detail design, and the National Fire Protection Association, National Electrical Code, NFPA 70, current edition in effect at detail engineering, and appropriate industry codes and standards.

Table 3.4-4 Product Take-off System Design Basis

Equipment Requirements			
Component	**Quantity Per**		
	Cascade Hall	**Separations Building Module**	**Plant Total**
Product Pumping Trains	2	4	12
Product Pumps (2 Pumps in series per Train)	4	8	24
Product Low Temperature Take-off Stations	5	10	30
UF_6 cold traps	2	4	12
Vacuum Pump/Chemical Trap Sets	2	4	12

Flow – kg/hr (lb/hr)	**Per Cascade Hall**
Maximum	18.4 (40.6)

First Pump, Product Pumping Train	
Nominal Pump Capacity, m^3/hr (cfm)	2,000 (1,177)
Inlet Pressure, mbar (in. H_2O)	2 (0.803)

Second Pump, Product Pumping Train	
Nominal Pump Capacity, m^3/hr (cfm)	500 (294)
Maximum Outlet Pressure, mbar (in. H_2O)	80 (32.1)

Table 3.4-4 Product Take-off System Design Basis
Page 2 of 5

Product Low Temperature Take-off Station	
Number Per Cascade Hall	5
On-line	2
Standby	2
Preparation/Maintenance	1
Cylinder Type	30B or 48Y
Capacity UF_6, kg (lb)	2,277 or 12,501 (5,021 or 27,565)
Heating	
Heating Requirements	Cylinder Valve Hot Air Blower
Temperature, °C (°F)	63 (145)
Cooling	
Medium	Air, via dedicated chiller
Media Temperature, °C (°F)	-25 (-13)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	16,000 (35,300)

Table 3.4-4 Product Take-off System Design Basis
Page 3 of 5

Product Vent UF_6 Cold Trap	
Number Per Cascade Hall	2
Available, On-line	1
Spare (Standby, Prep, Maintenance)	1
Capacity, kg (lb) UF_6	25 (55.1)
Cool Down / Desubliming	
Operating Temperature, °C (°F)	-60 (-76)
Heat Up / Subliming	
Operating Temperature, °C (°F)	20 (68)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	To be determined at final design.

Table 3.4-4 Product Take-off System Design Basis
Page 4 of 5

Product Vent Vacuum Pump/Chemical Trap Set				
Number Per Cascade Hall			2	
Available, On-line			1	
Spare (Standby, Prep, Maintenance)			1	
Vacuum Pump				
Capacity, m^3/hr (cfm)			40 (23.5)	
Chemical Traps (Note 1)				
Type	Chemical	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	HF Removal	Oil Removal	Oil Removal
Count	One	One	One	One
Media	Activated Carbon	Aluminum Oxide (Al_2O_3)	Al_2O_3	Activated Carbon

Note 1: Each Vacuum Pump/Chemical Trap Set has the above chemical traps.

Nitrogen Purge	
Operating Pressure, mbar (psia)	<1,000 (14.5)
Gas Usage	Intermittent flow in small quantities.

Table 3.4-4 Product Take-off System Design Basis
Page 5 of 5

Assay Sampling Pump/Chemical Trap Set			
Number Per Cascade Hall		1	
Vacuum Pump			
Capacity, m^3/hr (cfm)		40 (23.5)	
Chemical Traps			
Type	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	Oil Removal	Oil Removal
Count	One	One	One
Media	Activated Carbon	Al_2O_3	Activated Carbon

Table 3.4-5 Product Take-off System Codes and Standards

Page 1 of 1

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the Product Take-off System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the Product Take-off System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 material handling equipment in the Product Take-off System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the Product Take-off System.
All process piping in the Product Take-off System shall meet or exceed the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail design.
All 30-in and 48-in cylinders used in the Product Take-off System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.4-6 Tails Take-off System Design Basis

Equipment Requirements			
Component	**Quantity Per**		
	Cascade Hall	**Separations Building Module**	**Plant Total**
Tails Pumping Trains	16	32	96
Tails Pumps (Two Pumps in series per Train)	32	64	192
Tails Low Temperature Take-off Stations	10	20	60
Tails Evacuation Pump/Chemical Trap Sets	1	2	6

Flow – kg/hr (lb/hr)	**Per Cascade Hall**
Maximum	168 (370)
Dump Peak	256 (564)

First Pump, Tails Pumping Train	
Nominal Pump Capacity, m^3/hr (cfm)	2,000 (1,177)
Inlet Pressure, mbar (in. H_2O)	2 (0.80)

Second Pump, Tails Pumping Train	
Nominal Pump Capacity, m^3/hr (cfm)	500 (294)
Maximum Outlet Pressure, mbar (in. H_2O)	55 (22.1)

Table 3.4-6 Tails Take-off System Design Basis
Page 2 of 3

Tails Low Temperature Take-off Station	
Number Per Cascade Hall	10
On-line	7
Standby	1
Preparation/Maintenance	2
Cylinder Type	48Y
Capacity UF_6, kg (lb)	12,501 (27,565)
Heating	
Heating Requirements	Cylinder Valve Hot Air Blower
Temperature, °C (°F)	63 (145)
Cooling	
Medium	Air, via dedicated chiller
Media Temperature, °C (°F)	-25 (-13)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	16,000 (35,300)

Table 3.4-6 Tails Take-off System Design Basis
Page 3 of 3

Tails Evacuation Pump/Chemical Trap Set				
Number Per Cascade Hall			1	
Vacuum Pump				
Capacity, m^3/hr (cfm)			40 (23.5)	
Chemical Traps				
Type	Chemical	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	HF Removal	Oil Removal	Oil Removal
Count	One	One	One	One
Media	Activated Carbon	Aluminum Oxide (Al_2O_3)	Al_2O_3	Activated Carbon

Nitrogen Purge	
Operating Pressure, mbar (psia)	<1,000 (14.5)
Gas Usage	Intermittent flow in small quantities.

Table 3.4-7 Tails Take-off System Codes and Standards

Page 1 of 1

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the Tails Take-off System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the Tails Take-off System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 material handling equipment in the Tails Take-off System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the Tails Take-off System.
All process piping in the Tails Take-off System shall meet or exceed the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail design.
All 48-in cylinders used in the Tails Take-off System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.4-8 Product Blending System Design Basis

Equipment Requirements	
Component	**Number Required (Plant Total)**
Blending Donor Stations and Associated Valve Hot Boxes	2
Blending Receiver Stations and Associated Valve Hot Boxes	4
Blending and Sampling Vent Subsystem UF_6 cold traps	1
Blending and Sampling Vent Subsystem Pump/Chemical Trap Sets	1

Blending Donor Stations	
Number per Plant (Total)	2
On-line	1 or 2
Standby, Preparation, Maintenance	1 or 2
Heating Requirements	Air, via dedicated heater
Cylinder Type	30B or 48Y
Capacity UF_6, kg (lb)	2,277 or 12,501 (5,021 or 27,565)
Temperature, °C (°F)	61 (142)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	16,000 (35,300)

Table 3.4-8 Product Blending System Design Basis
Page 2 of 3

Blending Receiver Stations	
Number per Plant (Total)	4
On-line	1 to 4
Standby, Preparation, Maintenance	1 to 4
Cylinder Type	30B
Capacity UF_6, kg (lb)	2,277 (5,021)
Cooling	
Medium	Air, via dedicated chiller
Temperature, °C (°F)	-25 (-13)
Heating	
Heating Requirements	Cylinder Valve Hot Air Blower
Temperature, °C (°F)	63 (145)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	4,000 (8,820)

Donor and Receiver Station Valve Hot Boxes		
Heating Media	Donor	Receiver
Media	Electrical Trace	Electrical Trace
Temperature, °C (°F)	60 (140)	60 (140)

Table 3.4-8 Product Blending System Design Basis
Page 3 of 3

Blending and Sampling Vent UF_6 Cold Trap	
Number per Plant (Total)	1
Capacity, kg (lb) UF_6	25 (55.1)
Cool Down/Desubliming	
Operating Temperature, °C (°F)	-60 (-76)
Heat Up/Subliming	
Operating Temperature, °C (°F)	20 (68)
Weighing System	
Type	Load Cell
Capacity, kg (lb)	To be determined in final design.

Blending and Sampling Vent Vacuum Pump/Chemical Trap Set				
Number per Plant (Total)		1		
Vacuum Pump				
Nominal Capacity, m^3/hr (cfm)		40 (23.5)		
Chemical Traps				
Type	Chemical	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	HF Removal	Oil Removal	Oil Removal
Count	One	One	One	One
Media	Activated Carbon	Aluminum Oxide (Al_2O_3)	Al_2O_3	Activated Carbon

Nitrogen Purge	
Operating Pressure, mbar (psia)	<1,000 (14.5)
Gas Usage	Intermittent flow in small quantities.

Table 3.4-9 Product Blending System Codes and Standards

Page 1 of 1

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the Product Blending System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the Product Blending System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 material handling equipment in the Product Blending System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the Product Blending System.
All process piping in the Product Blending System shall meet or exceed the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition.
All 30-in and 48-in cylinders used in the Product Blending System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.4-10 Product Liquid Sampling System Design Basis

Equipment Requirements	
Component	**Number Required (Total Plant)**
Product Liquid Sampling Systems	1
Product Liquid Sampling Autoclaves	5

Capacity Requirements	
Product Cylinders	Equivalent 9 / week

Product Liquid Sampling Autoclaves	
Design Pressure, bar absolute (psia)	12 (174) and Full Vacuum
Design Temperature, °C (°F)	160 (320) (Pressure Vessel) 120 (248) (Seals, Instruments)
Autoclave Cooling Water, °C (°F)	6 (42.8)

Product Cylinder	
Cylinder Type	30B
Capacity UF_6, kg (lb)	2,277 (5,021)

Product Sampling Manifold	
Sample Bottle Type	1S
Maximum Net Weight per bottle, kg (lb) UF_6	0.45 (0.99)
Minimum Volume per bottle, L (gal)	0.15 (0.04)

Table 3.4-11 Product Liquid Sampling System Codes and Standards

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Product Liquid Sampling Autoclaves and their supports are designed to meet the requirements of the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section VIII, Division I, current edition at the time of detail design.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the Product Liquid Sampling System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the Product Liquid Sampling System.
Material handling equipment is designed in accordance with the appropriate industry codes and standards and the requirements of the Occupational Safety and Health Administration. There is no QA Level 1 material handling equipment in the Product Liquid Sampling System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the Product Liquid Sampling System.
All process piping in the Product Liquid Sampling System shall meet or exceed the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail design.
All 1.5-in and 30-in cylinders used in the Product Liquid Sampling System comply with the requirements of ANSI N14.1, Uranium Hexafluoride Packaging for Transport, version in effect at the time of cylinder manufacture.

Table 3.4-12 Contingency Dump System Design Basis
Page 1 of 2

Equipment Requirements			
Components	**Quantity per**		
	Cascade Hall	**Plant Module**	**Plant Total**
Sodium Fluoride Trap	24	48	144
Buffer Volume	8	16	48
Vacuum Pump/ Chemical Trap Set	8	16	48

System Capacity	**Per Cascade Hall**
Peak Dump Flow, kg/hr (lb/hr)	38.1 (84.0)
Dump Capacity, kg (lb)	15 (33.1)
Dump Time, hr	18

Chemical Trap	
Type	Sodium Fluoride Trap
Capacity UF_6, kg (lb)	100 (221)

Contingency Dump Vacuum Pump/Chemical Trap Set				
Vacuum Pump				
Capacity, m^3/hr (cfm)	40 (23.5)			
Chemical Traps				
Type	Chemical	Chemical	Adsorption	Adsorption
Function	UF_6 Removal	HF Removal	Oil Removal	Oil Removal
Count	1	1	1	1
Media	Activated Carbon	Aluminum Oxide (Al_2O_3)	Al_2O_3	Activated Carbon

Table 3.4-12 Contingency Dump System Design Basis
Page 2 of 2

Piping Headers	
Buffer Volume	
Volume, m^3 (ft^3)	1 (35.3)
Operating Pressure, mbar (in. H_2O)	Classified
Temperature, °C (°F)	Ambient
Primary Header	
Operating Pressure, mbar (in. H_2O)	Classified
Temperature, °C (°F)	Ambient
Secondary Header	
Operating Pressure, mbar (in. H_2O)	Classified
Temperature, °C (°F)	Ambient

Table 3.4-13 Contingency Dump System Codes and Standards

The equipment IROFS are designed, constructed, tested, and maintained to QA Level 1. IROFS design criteria are included in Section 3.8.1, IROFS.
Rotating equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 rotating equipment in the Contingency Dump System.
Heat transfer equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 heat transfer equipment in the Contingency Dump System.
All miscellaneous equipment is designed in accordance with the appropriate industry codes and standards. There is no QA Level 1 miscellaneous equipment in the Contingency Dump System.
All process piping in the Contingency Dump System meets or exceeds the requirements of American Society of Mechanical Engineers, Process Piping, ASME B31.3, current edition at the time of detail design.

Table 3.4-14 Gaseous Effluent Vent System Codes and Standards

Equipment Type	Code or Standard
Air Handling Units	NFPA 90A, 1999 AMCA Pub. 99 – 1986 AMCA Pub. 261 – 1998 ARI 430 – 1980 NEMA MG – 1998 REV. 3
Fans/Motors	AMCA 210 – 1999 ASHRAE 51 – 1999 ASHRAE Systems and Equipment 2000 NEMA MG1 – 1998 REV. 3
Coils	ANSI/ARI 410 – 2001
Air Cleaning Devices	ASME AG-1-1997 ERDA 76-21 – 1976 ANSI/ASME N509 – 1989 (R1996) ANSI/ASME N510 – 1989 (R1995) ASME NQA-1 – 2001 ASTM D6646-03 ANSI/AWS-D9.1 – 2000
Dampers	UL-Building Materials Directory

Table 3.4-15 Gaseous Effluent Vent System Design Bases (Separations Building)

Equipment Requirements	
Item	Quantity
Filter Stations (prefilter, HEPA, activated carbon filter)	1 + 1 spare
Fans	1 + 1 spare
System Design Flow Rate	11,000 m^3/hr (6474 scfm)
Filter Specifications	
Prefilter (Dust removal)	85%
HEPA Filter (Removal of uranium aerosols, mainly UO_2F_2 particles)	99.97% (for ≥ 0.3 μm particle size)
Activated Carbon Filter (HF removal)	99%

Table 3.4-16 Gaseous Effluent Vent System Design Bases (Technical Services Building)

Equipment Requirements	
Item	Quantity
Filter Stations (prefilter, HEPA, activated carbon filter)	1 (no spare)
Fans	1 (no spare)
System Design Flow Rate	18,700 m^3/hr (11,000 scfm)
Filter Specifications	
Prefilter (Dust removal)	85%
HEPA Filter (Removal of uranium aerosols, mainly UO_2F_2 particles)	99.97% (for ≥ 0.3 µm particle size)
Activated Carbon Filter (HF removal)	99%

Table 3.4-17 Functional Requirements for Centrifuge Test and Post Mortem Facilities

Page 1 of 1

Item	Test	Post Mortem
Temperature	18-25°C (64.4 – 77°F)	18-25°C (64.4 – 77°F)
Relative Humidity	55% max.	70% max.
Pressure	Ambient.	Negative pressure to prevent egress of airborne contaminated materials.
Handling	Floor based transport vehicle, jib crane.	Floor based transport vehicle, jib crane.
Physical Security	Access control for cleared personnel only.	Access control for cleared personnel only.
Personnel Facilities (common to both facilities).	Toilets, wash basins, shower, and change area.	Toilets, wash basins, shower, and change area.
Radiological Protection	Alpha in air monitors, HFC (hand foot clothing) monitor. Criticality incident detection system. PPE (gloves, overalls, face masks with appropriate filtration).	Alpha in air monitors, HFC (hand foot clothing) monitor. Criticality incident detection system. PPE (gloves, overalls, face masks with appropriate filtration).

Table 3.4-18 Utility Requirements for Centrifuge Test and Post Mortem Facilities

Page 1 of 1

Utilities	Test	Post Mortem
Electrical	440 VAC, 110 VAC, and 24VDC for instruments	Same
Liquid Nitrogen	Required	Not required
Nitrogen Gas	Required	Required
Compressed Air	Required	Required
HVAC	Required	Required
Centrifuge Test and Post Mortem Facilities Exhaust Filtration System	Three separate flexible exhaust hoses are required. One is located adjacent to the feed and take-off vessels to allow removal and recharging with UF_6. The remaining two are located at the top of each Centrifuge Cubicle, to provide local extract when breaking process connections. The exhaust of the rotary vane vacuum pump discharges into the Centrifuge Test and Post Mortem Facilities Exhaust Filtration System.	Required
Cooling Water	Proprietary stand-alone unit.	Not required

Table 3.4-19 UF_6 Feed Cylinder Delivery and Storage Requirements
Page 1 of 1

Feed Cylinders	
Code	ANSI-N14.1
Type (Typical)	48Y or 48X
Net UF_6 Capacity	12,501 kg (27,560 lbs)
Average Rate (Cylinders/Yr)	690
Handling	
Unloading	20 Metric Ton Bridge Crane
Transfer	Rail Transport
Storage	
No. Cylinders (1 Year Supply)	708
Area/Cylinder	8 m^2 (86 ft^2)
Stacking	No
Indoor/Outdoor	Indoor
Temperature	Ambient
Accountability Weighing System	
Type	Weigh Scale
Capacity	20,000 kg (44,092 lbs)
Accuracy	±2.5 kg (±5.5 lb)

Table 3.4-20 Crane Movement Requirements

Page 1 of 1

Cylinder Receipt and Dispatch Building	
Type	20 Metric Ton Bridge Crane
Quantity	2
Movements: (cylinders/yr)	
Feed Cylinders In	690
Product Cylinders Out	350
UBC Out	625
Empty Product In	350
Empty UBC In	625
Empty Feed Out	690
Total Crane Movements (Cylinders/Yr)	3330
UBC Storage Pad	
Type	20 Metric Ton Gantry Crane
Quantity	3
Movements: (cylinders/yr)	
UBC In	625
Empty Feed In	690
Empty Feed Out	690
Total Crane Movements (Cylinders/Yr)	2005

Table 3.4-21 UBC Storage System Requirements

Page 1 of 1

Cylinders	
Code	ANSI-N14.1
Type (Typical)	48Y
Net UF_6 Capacity	12,501 kg (27,560 lbs)
Rate (Cylinders/Yr)	625 maximum at full production
Storage	
No. Cylinders	15,727
Area/Cylinder	5.40 m^2 (58 ft^2)
Stacking	Yes (on concrete saddles)
Indoor/Outdoor	Outdoor
Temperature	Ambient

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FIGURES

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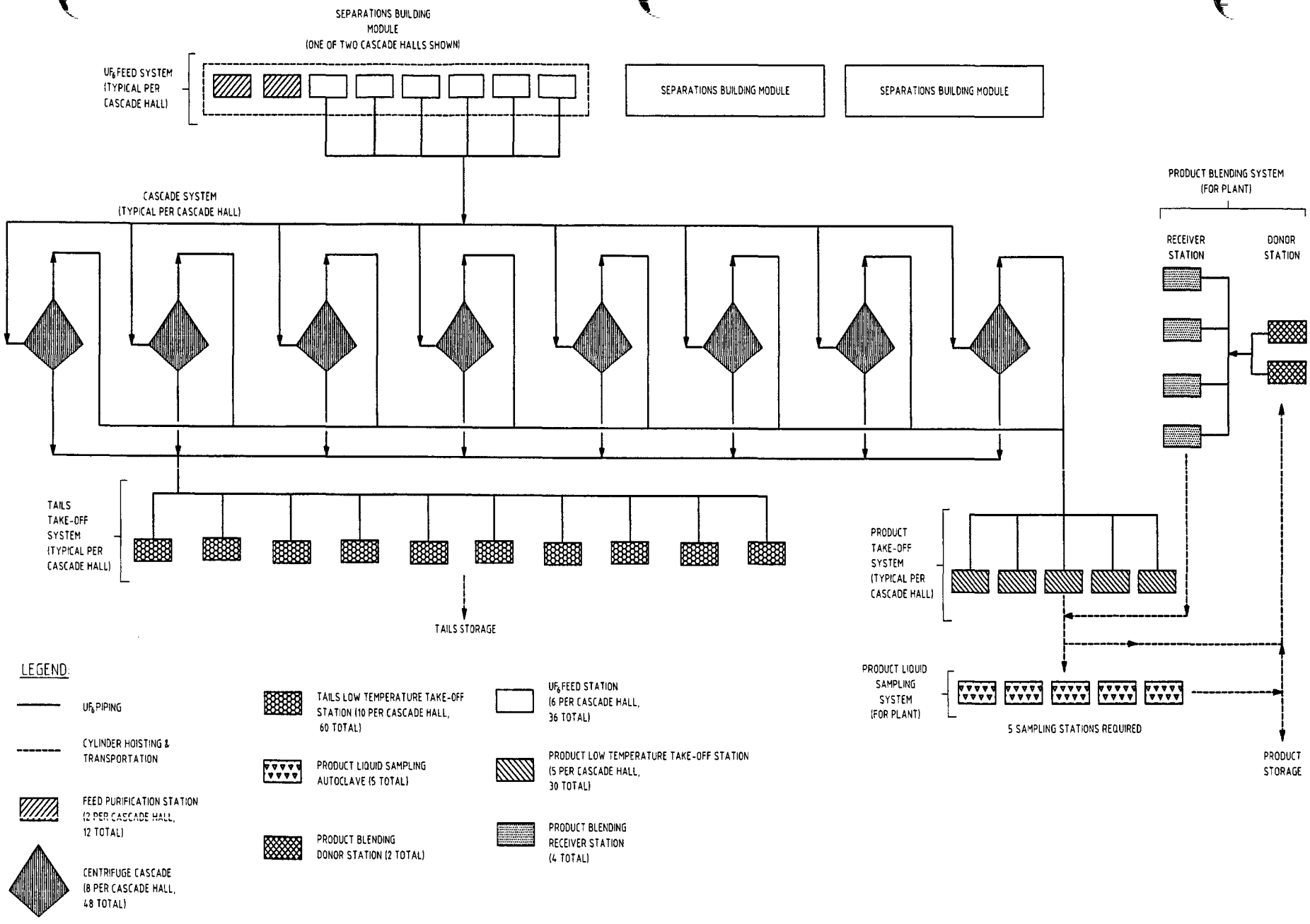

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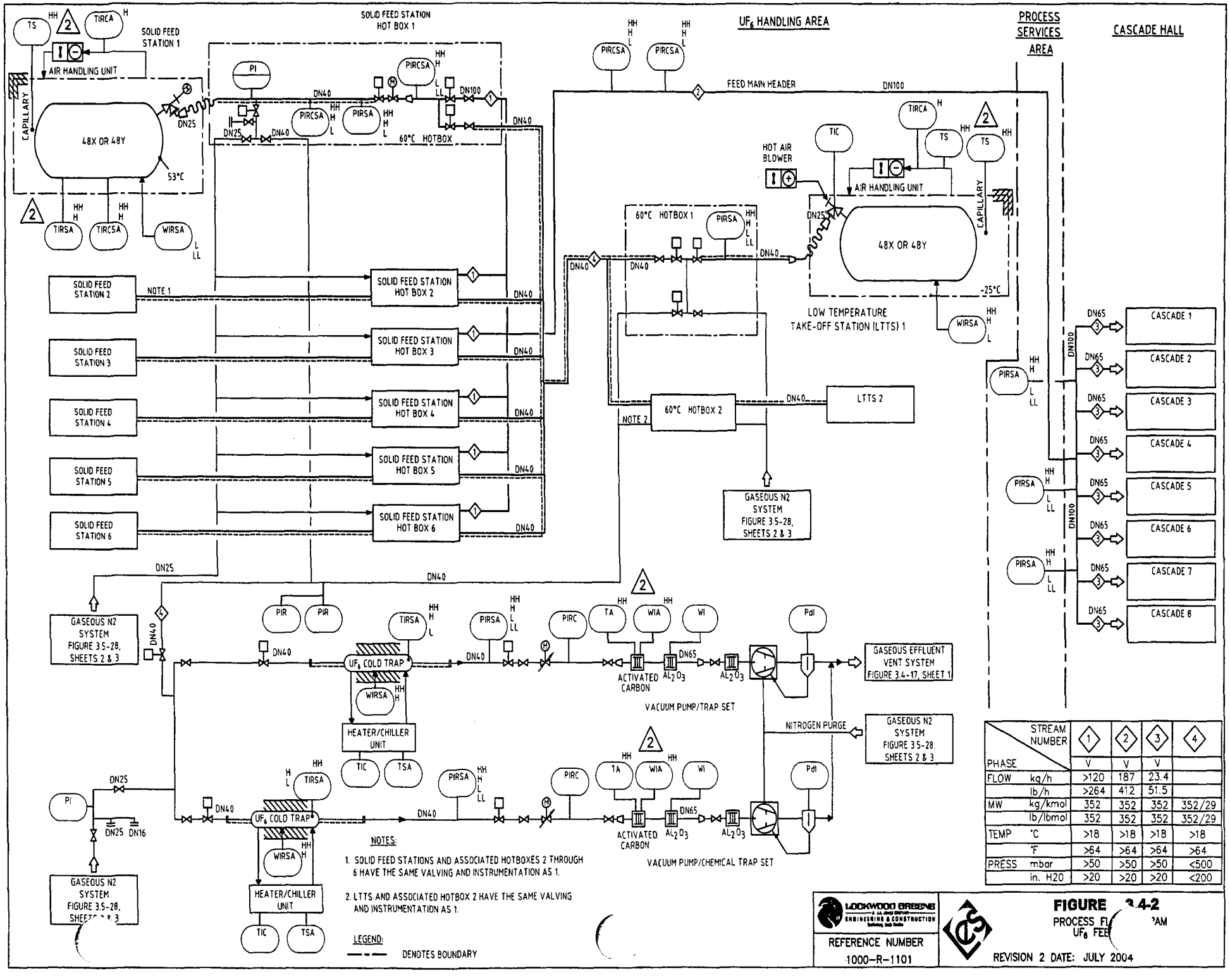
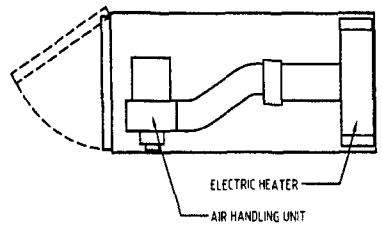
REFERENCE NUMBER
1000-R-1014

FIGURE 3.4-1
PICTORIAL REPRESENTATION OF THE ENRICHMENT PROCESS

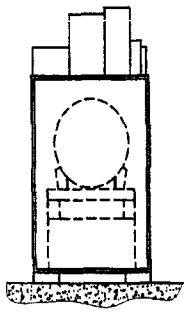
REVISION DATE: DECEMBER 2003



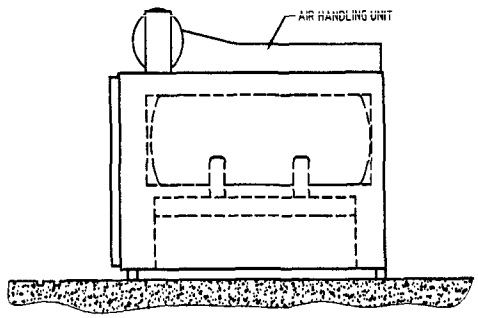
STREAM NUMBER		1	2	3	4
PHASE		V	V	V	
FLOW	kg/h	>120	187	23.4	
	lb/h	>264	412	51.5	
MW	kg/kmol	352	352	352	352/29
	lb/lbmol	352	352	352	352/29
TEMP	°C	>18	>18	>18	>18
	°F	>64	>64	>64	>64
PRESS	mbar	>50	>50	>50	<500
	in. H20	>20	>20	>20	<200



PLAN



END VIEW

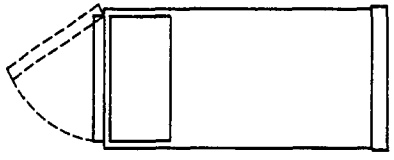


SIDE ELEVATION

REFERENCE NUMBER
0UC136321

FIGURE 3.4-3
SOLID FEED STATION
EQUIPMENT DRAWING

REVISION DATE: DECEMBER 2003



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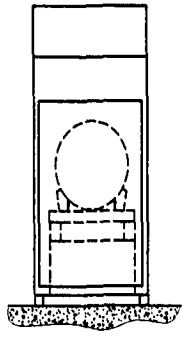

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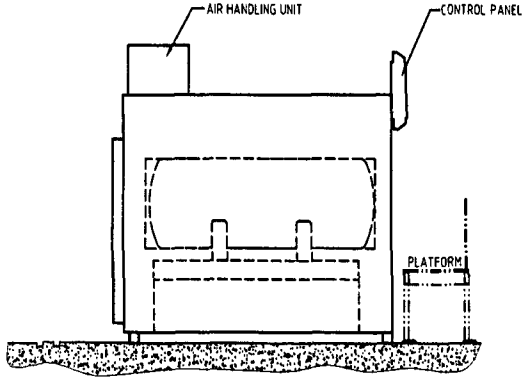
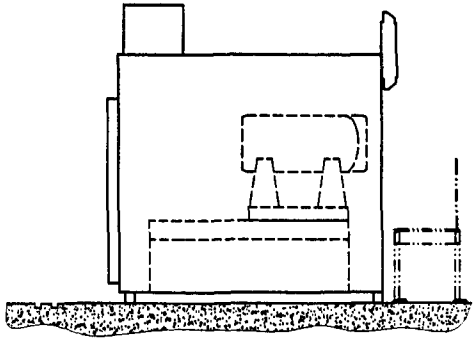


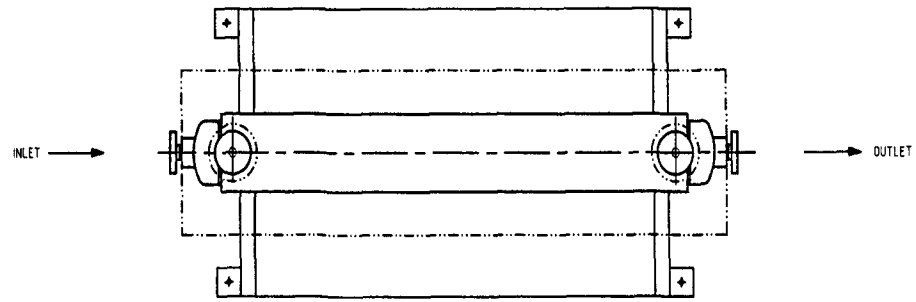
SIDE ELEVATION
(SHOWING 48" CYLINDER)



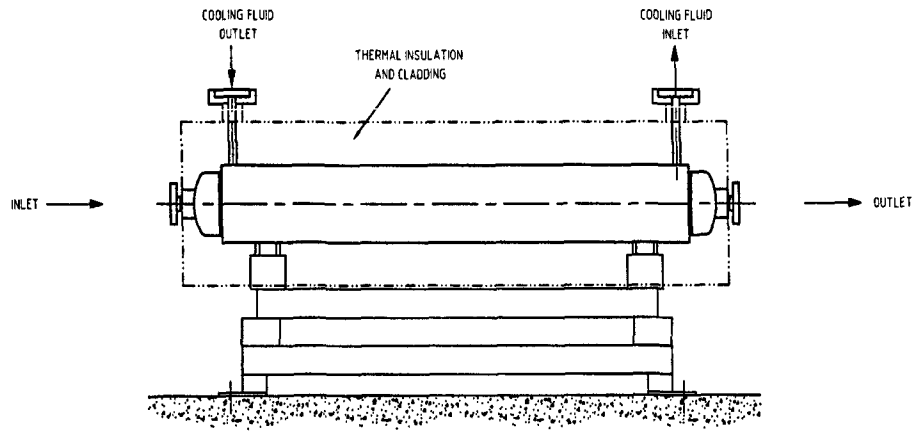
SIDE ELEVATION
(SHOWING 30" CYLINDER)

REFERENCE NUMBER
0UC136322

FIGURE 3.4-4
LOW TEMPERATURE [illegible] STATION
EQUIPMEN[illegible]
REVISION DATE: DECEMBER 20[illegible]



PLAN

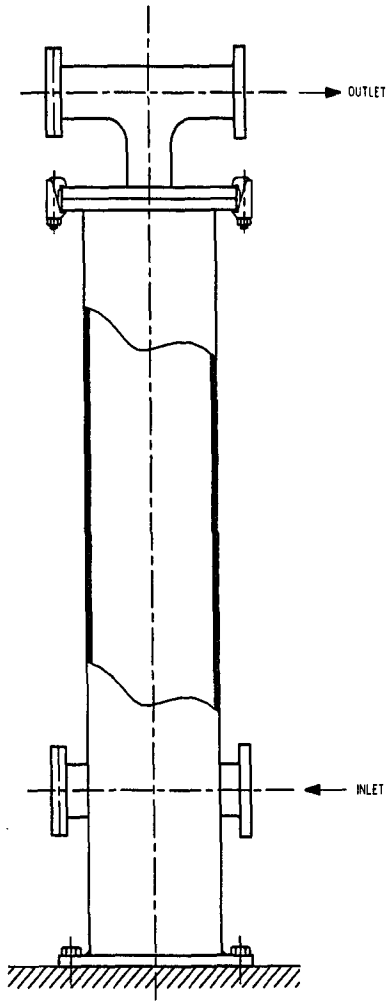


SIDE ELEVATION

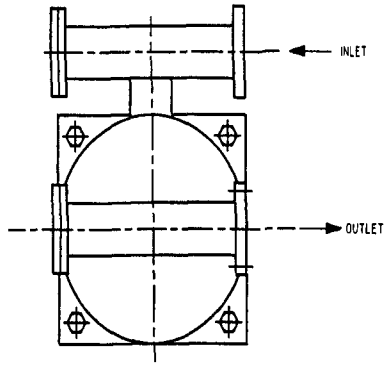
REFERENCE NUMBER
1UC136324

FIGURE 3.4-5
UF_6 COLD TRAP
EQUIPMENT DRAWING

REVISION DATE: DECEMBER 2003



SIDE ELEVATION

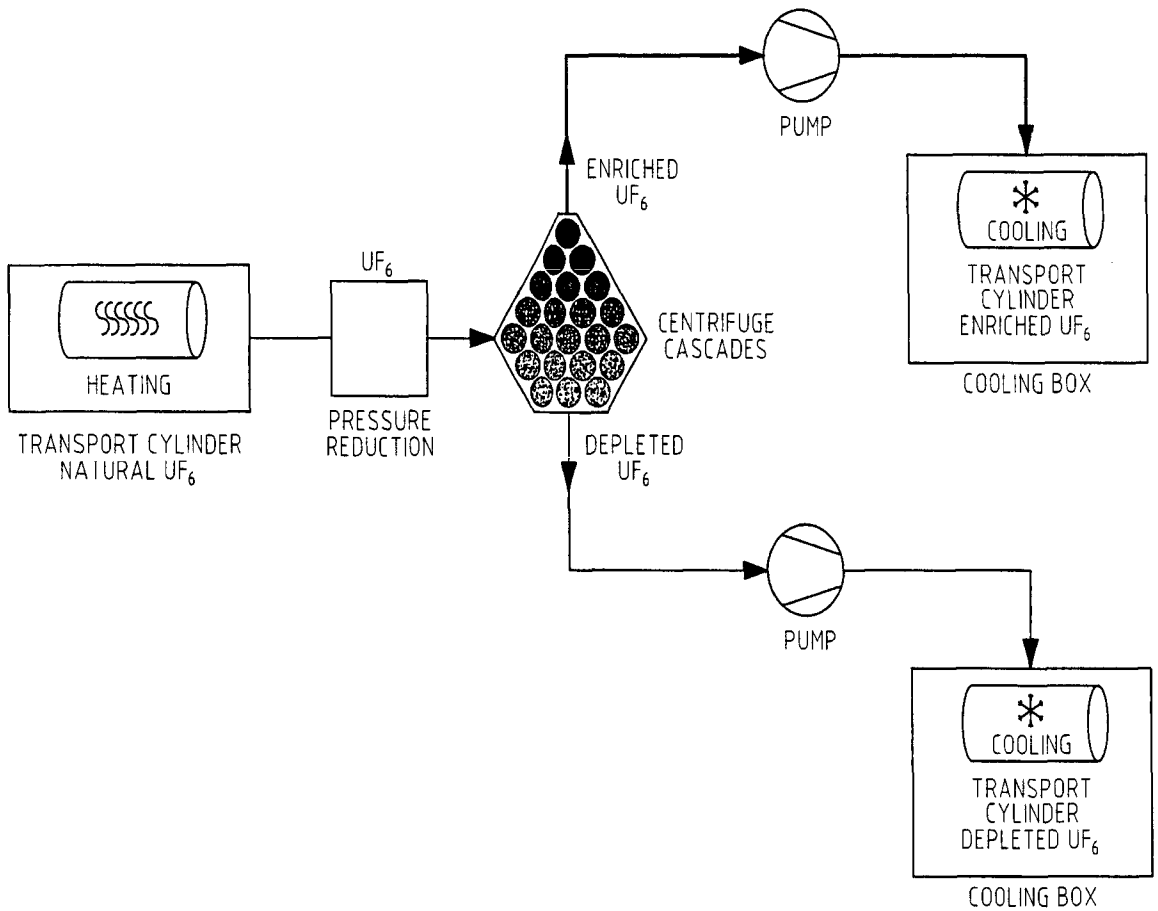


PLAN

REFERENCE NUMBER
0UC136326

FIGURE 3.4-6
CHEMICAL EQUIPMEN[illegible]G

REVISION DATE: DECEMBER [illegible]



REFERENCE NUMBER
3UC136328

FIGURE 3.4-7
THE ENRICHMENT PROCESS

REVISION DATE: DECEMBER 2003

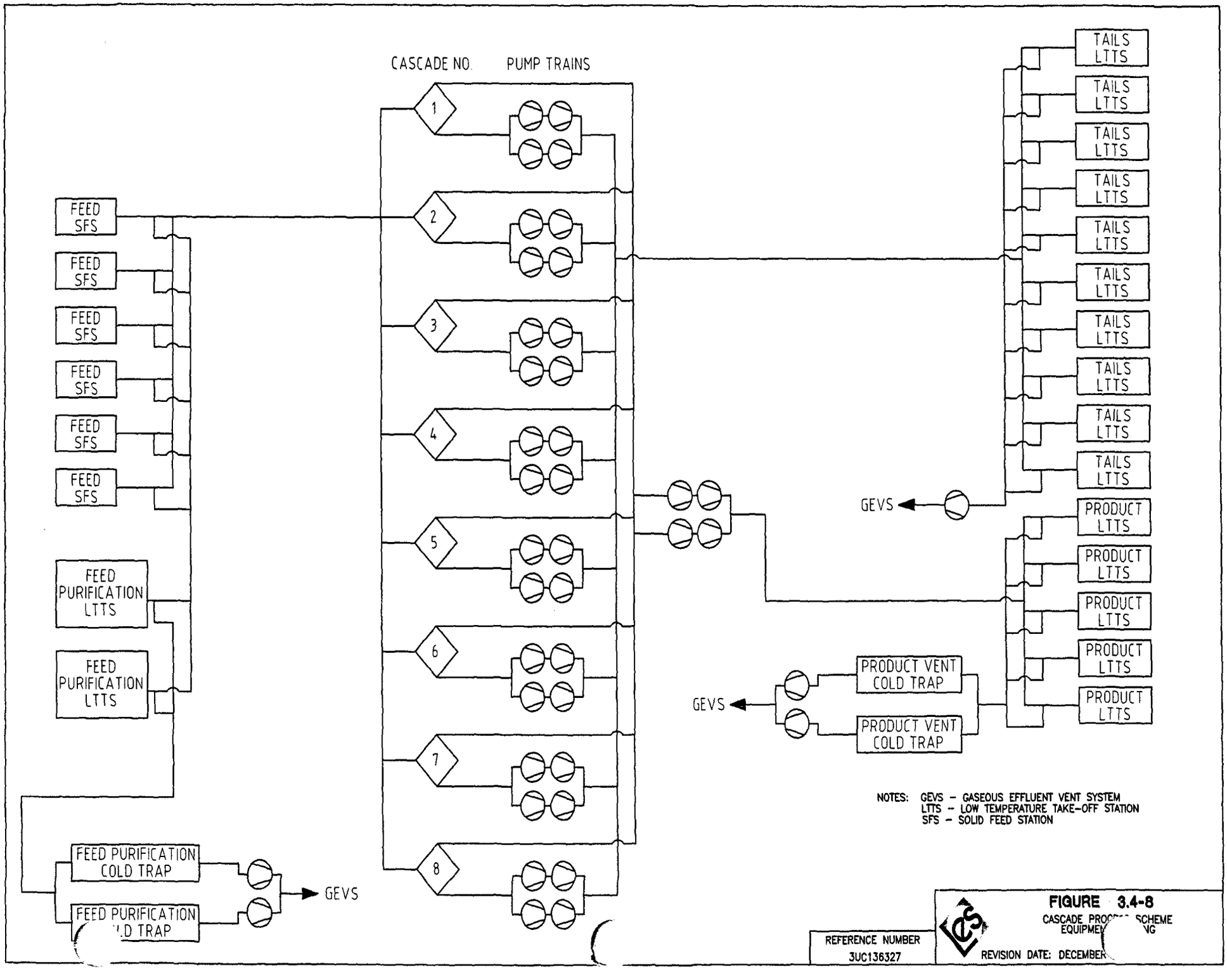


FIGURE 3.4-8
CASCADE PRO SCHEME
EQUIPME NG

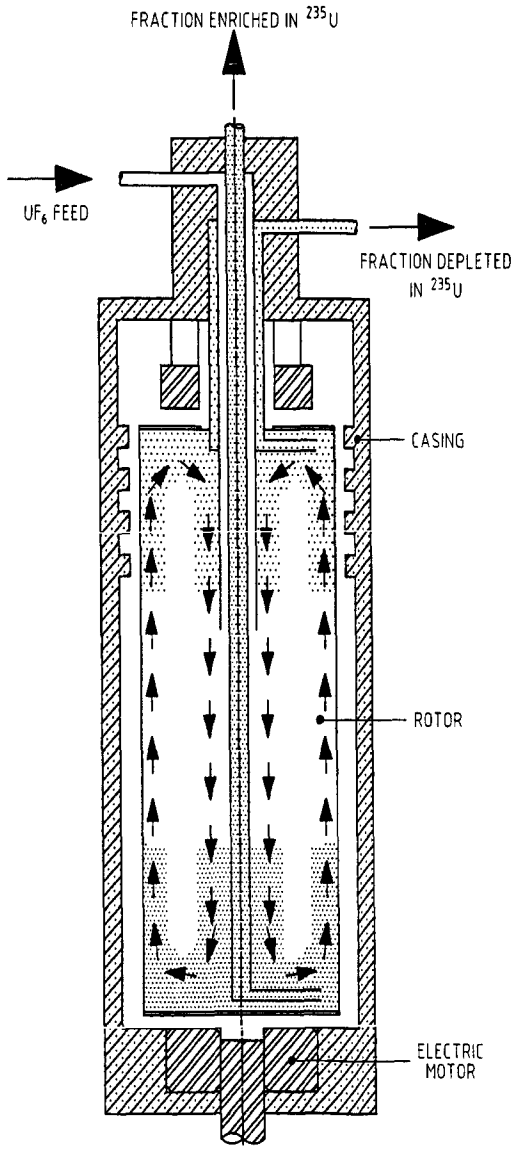
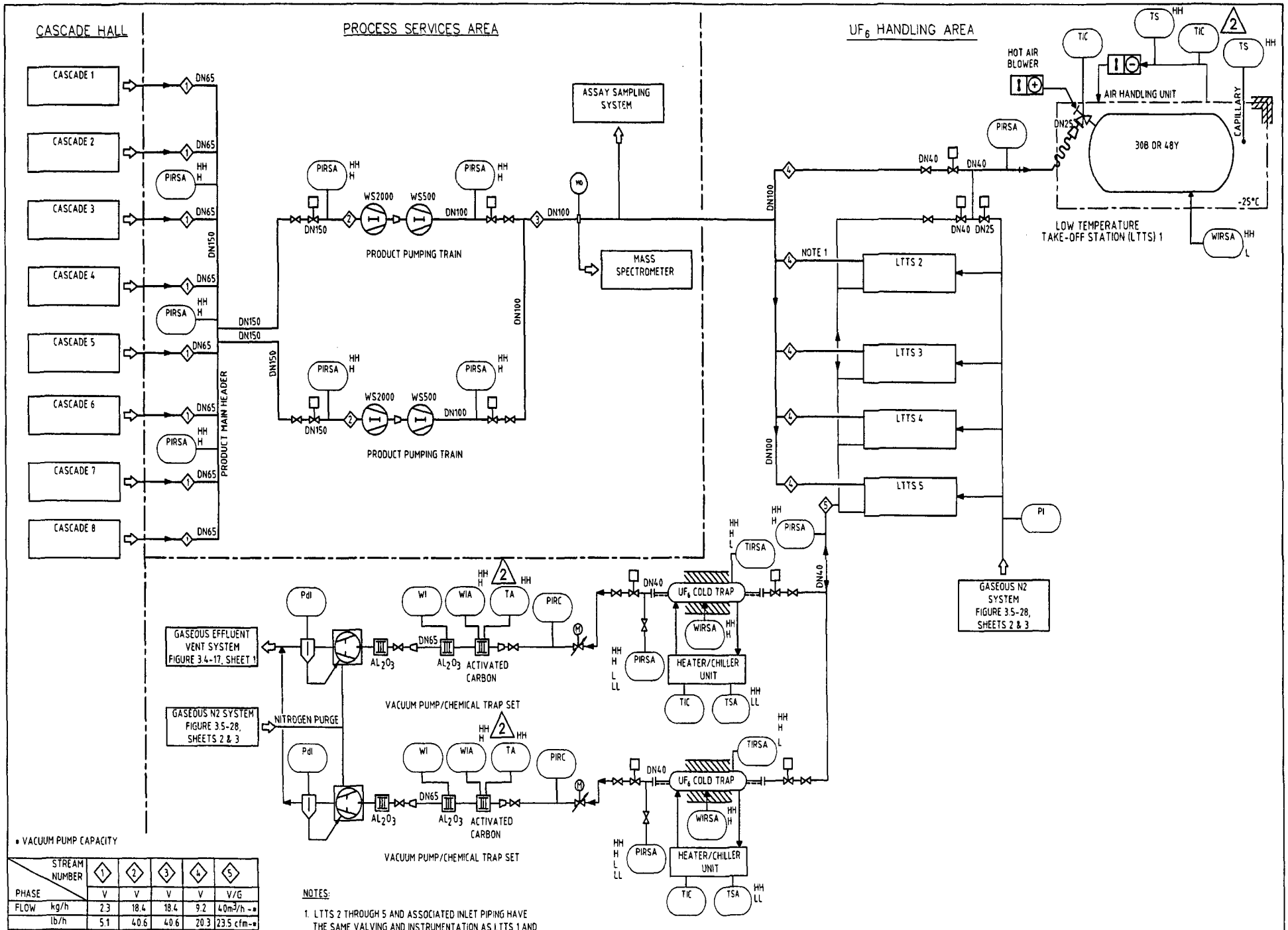


FIGURE 3.4-9
PRINCIPLE OF A GAS CENTRIFUGE

REFERENCE NUMBER
3UC136329

REVISION DATE: DECEMBER 2003



* VACUUM PUMP CAPACITY

PHASE	STREAM NUMBER	1	2	3	4	5
FLOW	kg/h	2.3	18.4	18.4	9.2	40m³/h -*
	lb/h	5.1	40.6	40.6	20.3	23.5 cfm-*
MW	kg/kmol	352	352	352	352	352/20/29
	lb/lbmol	352	352	352	352	352/20/29
TEMP	°C	>18	>18	>18	>18	>18
	°F		>64	>64	>64	>64
PRESS	mbar	< 2	≈ 55	≈ 50	< 90	
	in. H2O	< 0.80	< 22	< 20	< 36	

NOTES:

1. LTTS 2 THROUGH 5 AND ASSOCIATED INLET PIPING HAVE THE SAME VALVING AND INSTRUMENTATION AS LTTS 1 AND ITS ASSOCIATED INLET PIPING.

LEGEND:

DENOTES BOUNDARY

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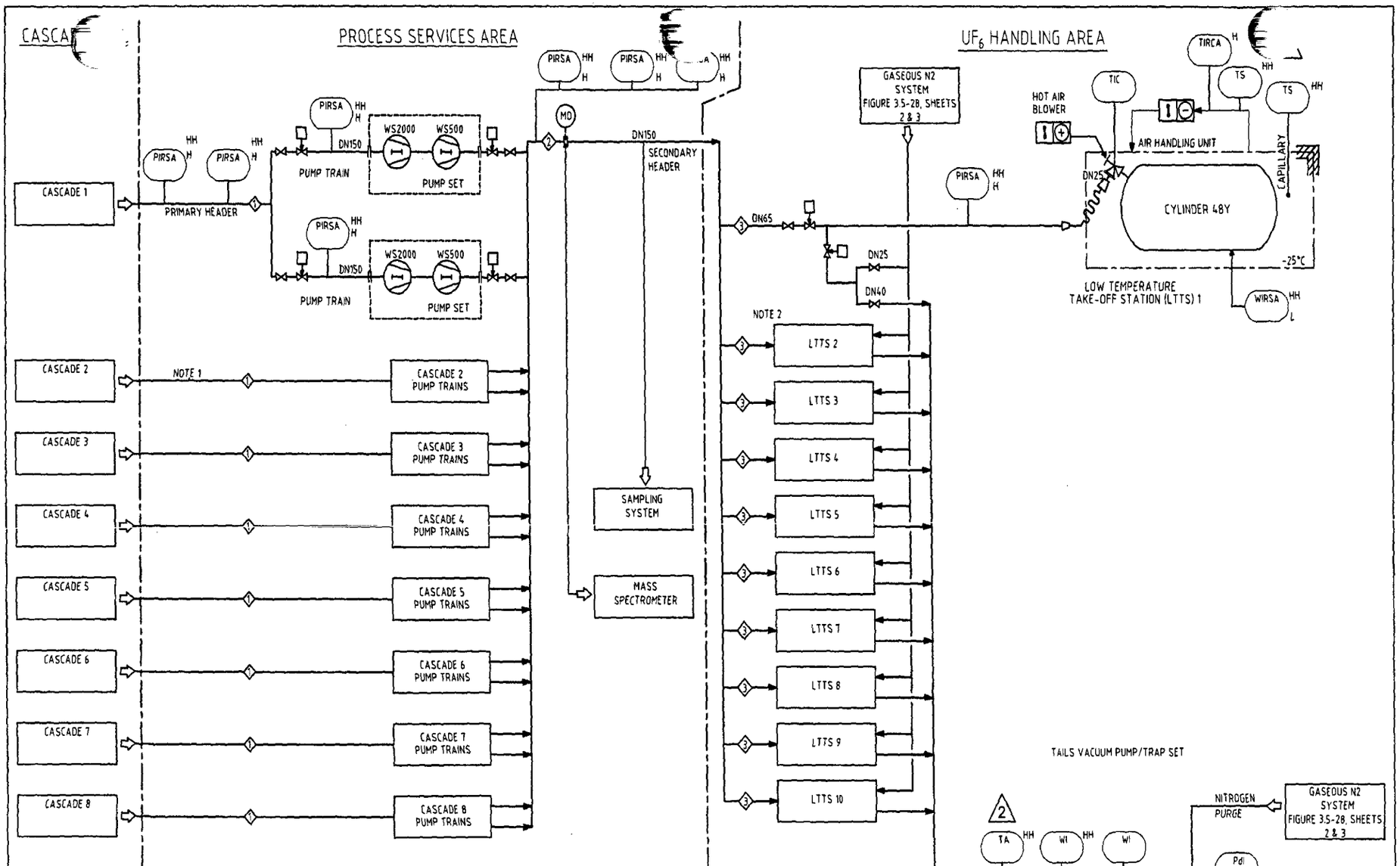
REFERENCE NUMBER 1000-R-1102

FIGURE 3.4-10

PROCESS FLO[illegible]RAM
PRODUCT TAK[illegible]STEM

REVISION 2 DATE: JULY 2[illegible]



* VACUUM PUMP CAPACITY

STREAM NUMBER		1	2	3	4
PHASE		V	V	V	V/G
FLOW	kg/h	<32	<256	<37	40m³/h *
	lb/h	<70.6	<564	<81.6	23.5 cfm *
MW	kg/kmol	352	352	352	352/20/29
	lb/lbmol	352	352	352	352/20/29
TEMP	°C	>18	>18	>18	>18
	°F	>64	>64	>64	>64
PRESS	mbar	<4	<70	<70	<1000
	in. H2O	<0.80	<28	<28	<401

NOTES:

1. CASCADE PRIMARY HEADER AND PUMP TRAINS 2 THROUGH 8 HAVE THE SAME VALVING AND INSTRUMENTATION AS CASCADE 1 PRIMARY HEADER AND PUMP TRAINS.
2. LTTS 2 THROUGH 10 AND ASSOCIATED INLET PIPING HAVE THE SAME VALVING AND INSTRUMENTATION AS LTTS 1 AND ITS ASSOCIATED INLET PIPING.

LEGEND:

— — — DENOTES BOUNDARY

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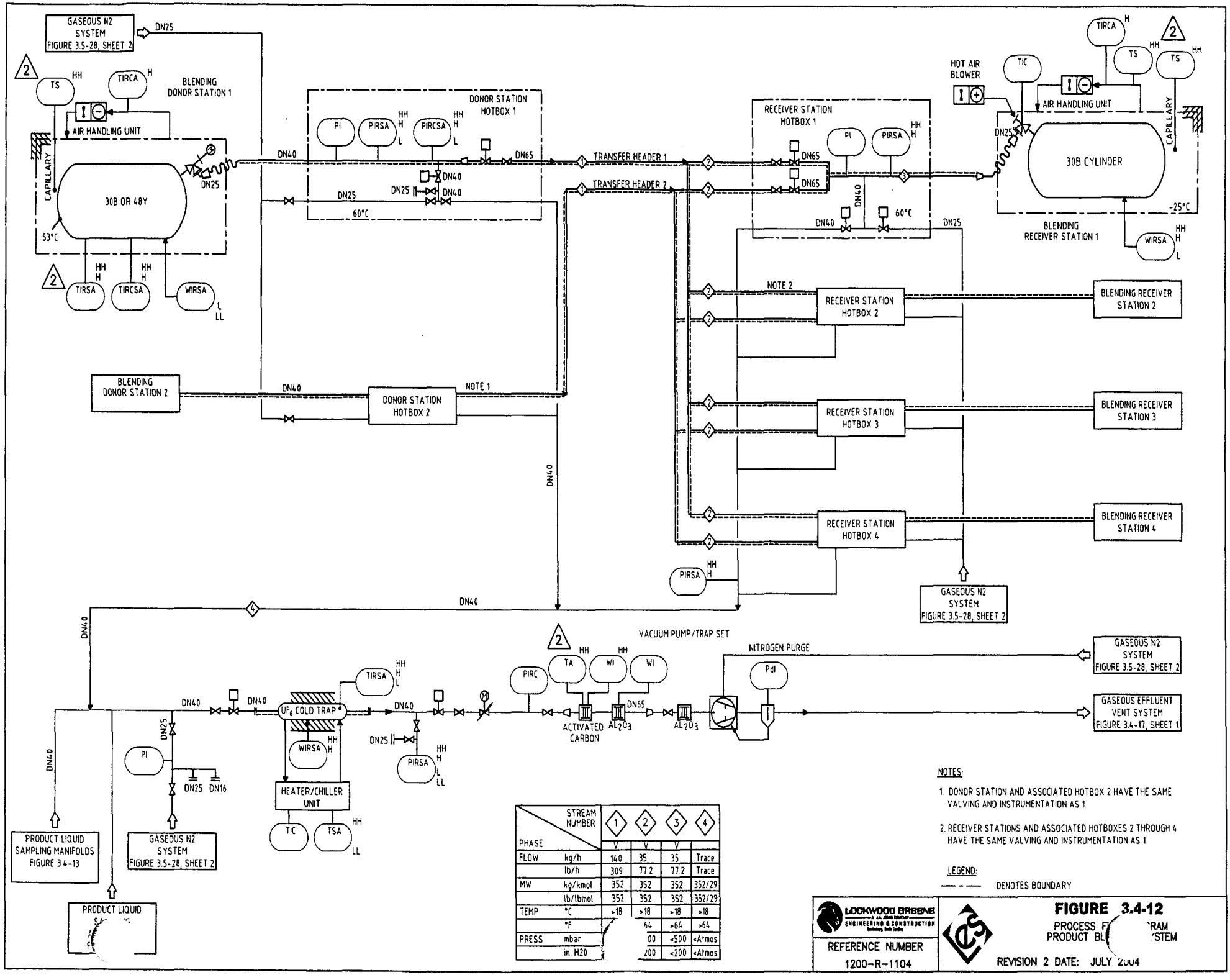
REFERENCE NUMBER 1000-R-1103

FIGURE 3.4-11

PROCESS FLOW DIAGRAM TAILS TAKE-OFF SYSTEM

REVISION 2 DATE: JULY 2004



PHASE	STREAM NUMBER	1	2	3	4
		V	V	V	
FLOW	kg/h	140	35	35	Trace
	lb/h	309	77.2	77.2	Trace
MW	kg/kmol	352	352	352	352/29
	lb/lbmol	352	352	352	352/29
TEMP	°C	>18	>18	>18	>18
	°F		64	>64	>64
PRESS	mbar		00	<500	<Atmos
	in. H20		200	<200	<Atmos

NOTES:

1. DONOR STATION AND ASSOCIATED HOTBOX 2 HAVE THE SAME VALVING AND INSTRUMENTATION AS 1.
2. RECEIVER STATIONS AND ASSOCIATED HOTBOXES 2 THROUGH 4 HAVE THE SAME VALVING AND INSTRUMENTATION AS 1.

LEGEND:

— — — DENOTES BOUNDARY

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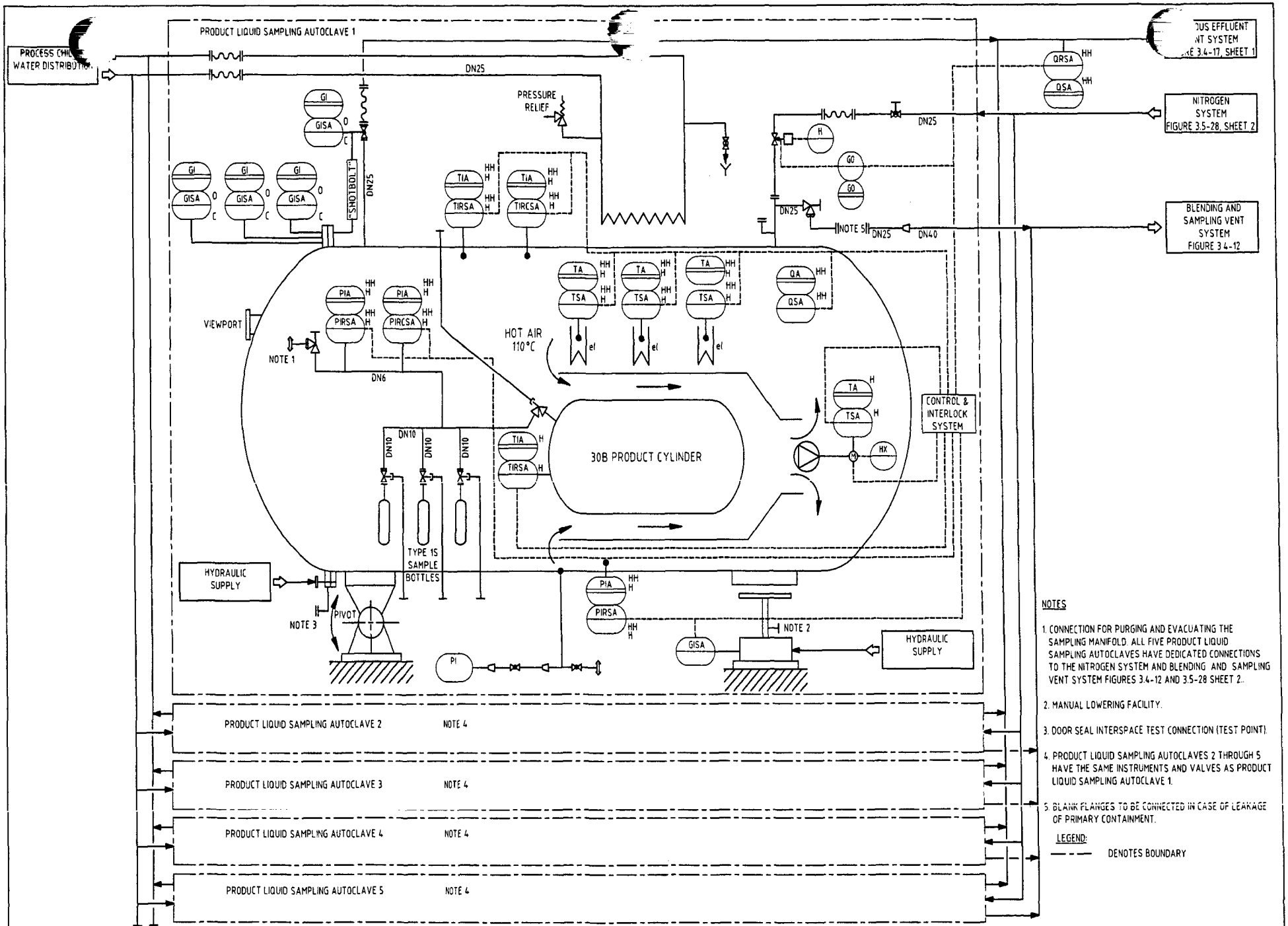
REFERENCE NUMBER 1200-R-1104

FIGURE 3.4-12

PROCESS F[illegible]RAM
PRODUCT BL[illegible]STEM

REVISION 2 DATE: JULY 2004



NOTES

1. CONNECTION FOR PURGING AND EVACUATING THE SAMPLING MANIFOLD. ALL FIVE PRODUCT LIQUID SAMPLING AUTOCLAVES HAVE DEDICATED CONNECTIONS TO THE NITROGEN SYSTEM AND BLENDING AND SAMPLING VENT SYSTEM FIGURES 3.4-12 AND 3.5-28 SHEET 2.
2. MANUAL LOWERING FACILITY.
3. DOOR SEAL INTERSPACE TEST CONNECTION (TEST POINT).
4. PRODUCT LIQUID SAMPLING AUTOCLAVES 2 THROUGH 5 HAVE THE SAME INSTRUMENTS AND VALVES AS PRODUCT LIQUID SAMPLING AUTOCLAVE 1.
5. BLANK FLANGES TO BE CONNECTED IN CASE OF LEAKAGE OF PRIMARY CONTAINMENT.

LEGEND:

— — — DENOTES BOUNDARY

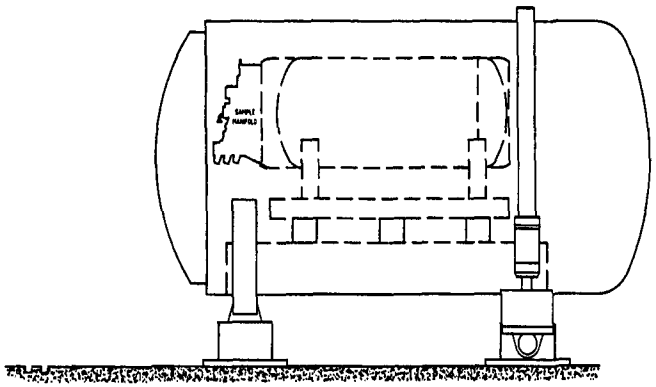
LOCKWOOD GREENE ENGINEERING & CONSTRUCTION

REFERENCE NUMBER 1200-R-1518

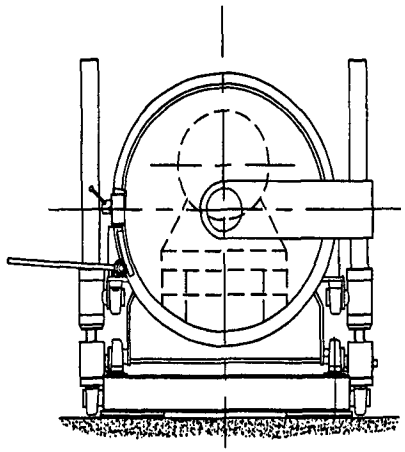
FIGURE 3.4-13

PROCESS FLOW DIAGRAM PRODUCT LIQUID SAMPLING SYSTEM

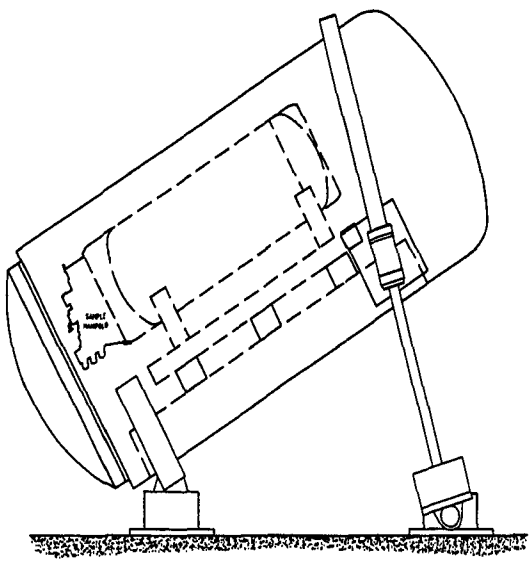
REVISION DATE: DECEMBER 2003



ELEVATION



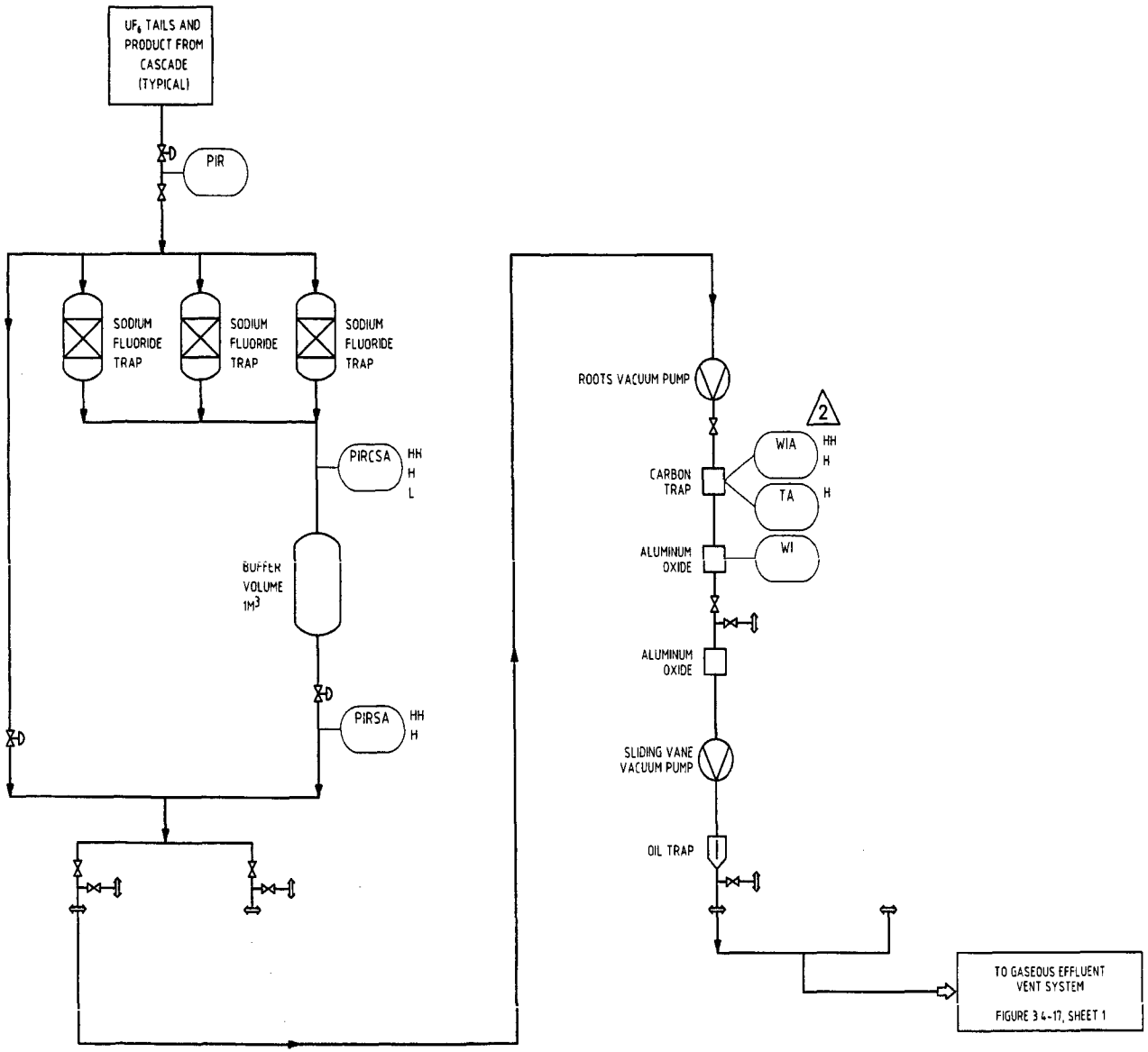
END VIEW



RAISED ELEVATION

REFERENCE NUMBER
0UC136323

FIGURE 3.4-14
LIQUID SAMPL[illegible] [illegible]CLAVE
EQUIPMEN[illegible] G
REVISION DATE: DECEMBER [illegible]



NOTE: THIS DIAGRAM IS TYPICAL FOR EACH CASCADE

LOCKWOOD GREENE
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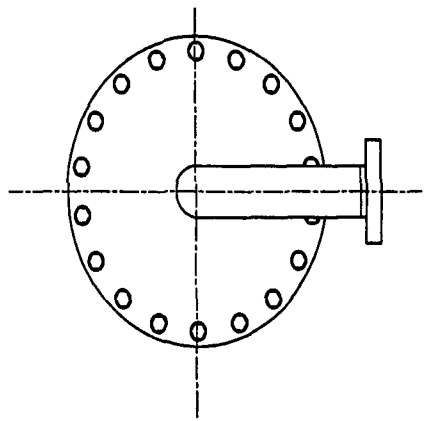
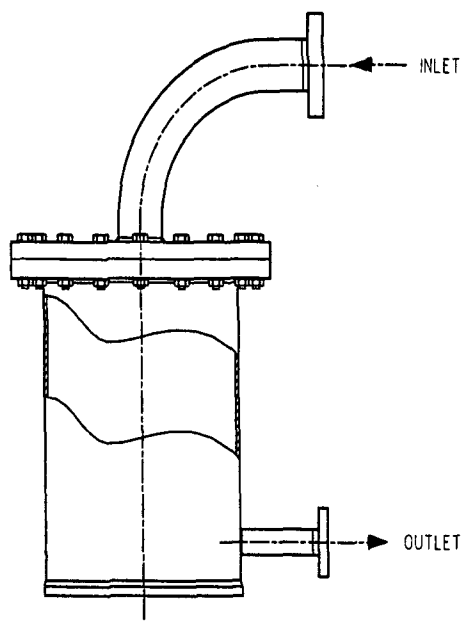
REFERENCE NUMBER
1000-R-1113

FIGURE 3.4-15
PROCESS FLOW DIAGRAM
CONTINGENCY DUMP SYSTEM

REVISION 2 DATE: JULY 2004



PLAN



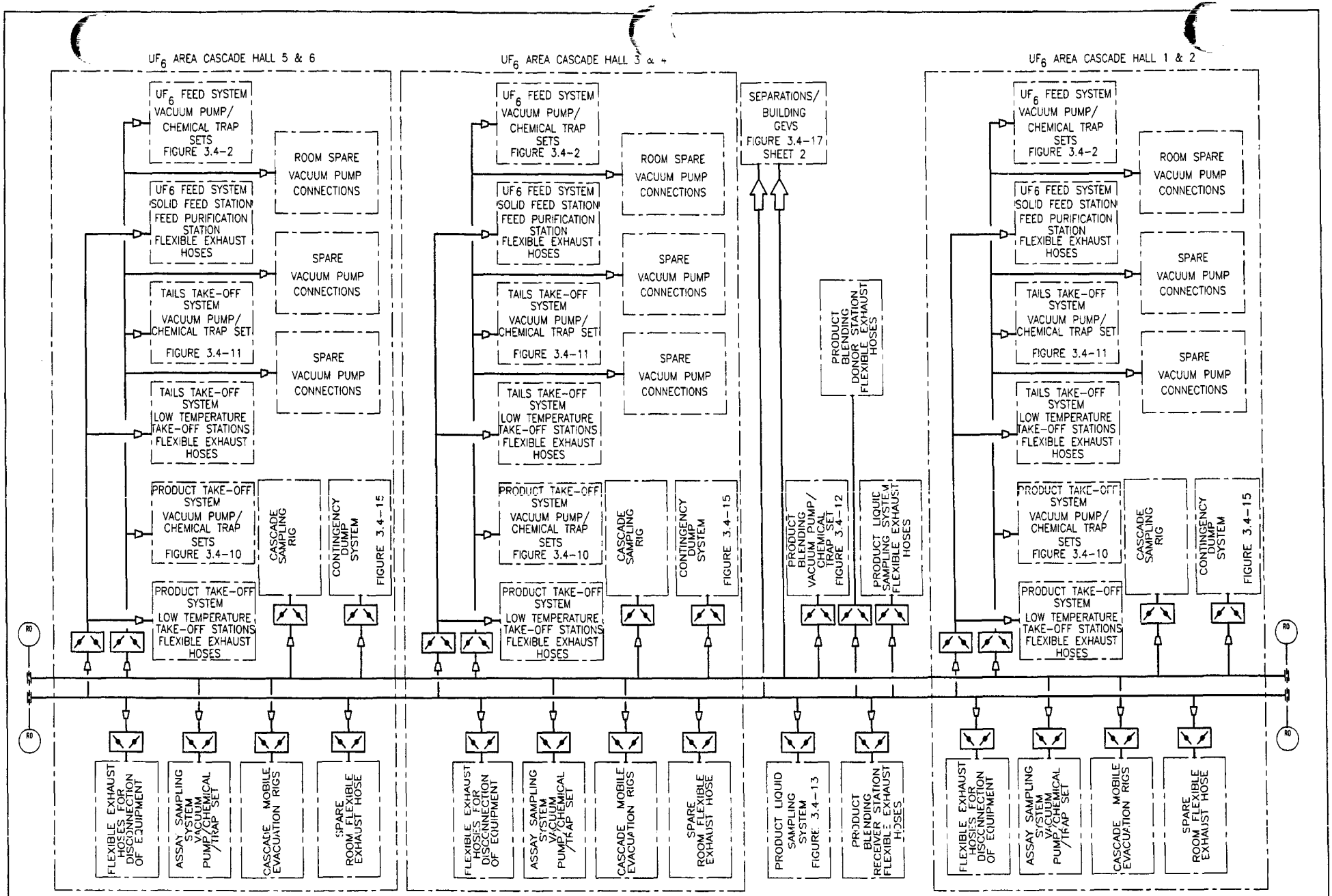
SIDE ELEVATION

REFERENCE NUMBER
3UC136330

FIGURE 3.4-16

NaF
EQUIPME G

REVISION DATE: DECEMBER



SHEET 1 OF 2

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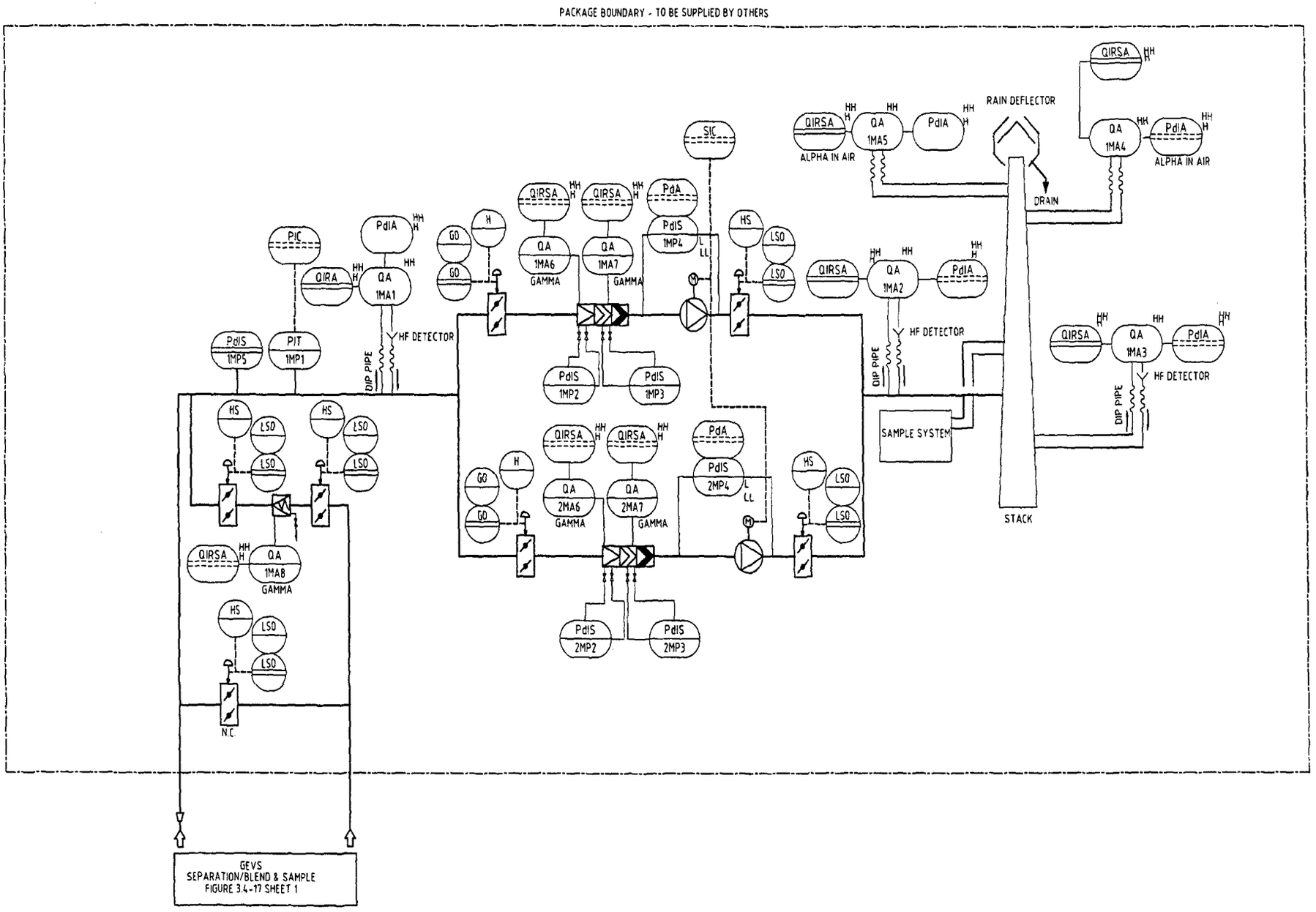
REFERENCE NUMBER
0664-M-1100

FIGURE 3.4-17

PROCESS FLOW DIAGRAM
GASEOUS EFFLUENT VENT SYSTEM
SEPARATIONS BUILDING

REVISION DATE: DECEMBER 2003



SHEET 2 OF 2

LOCKWOOD GREENE
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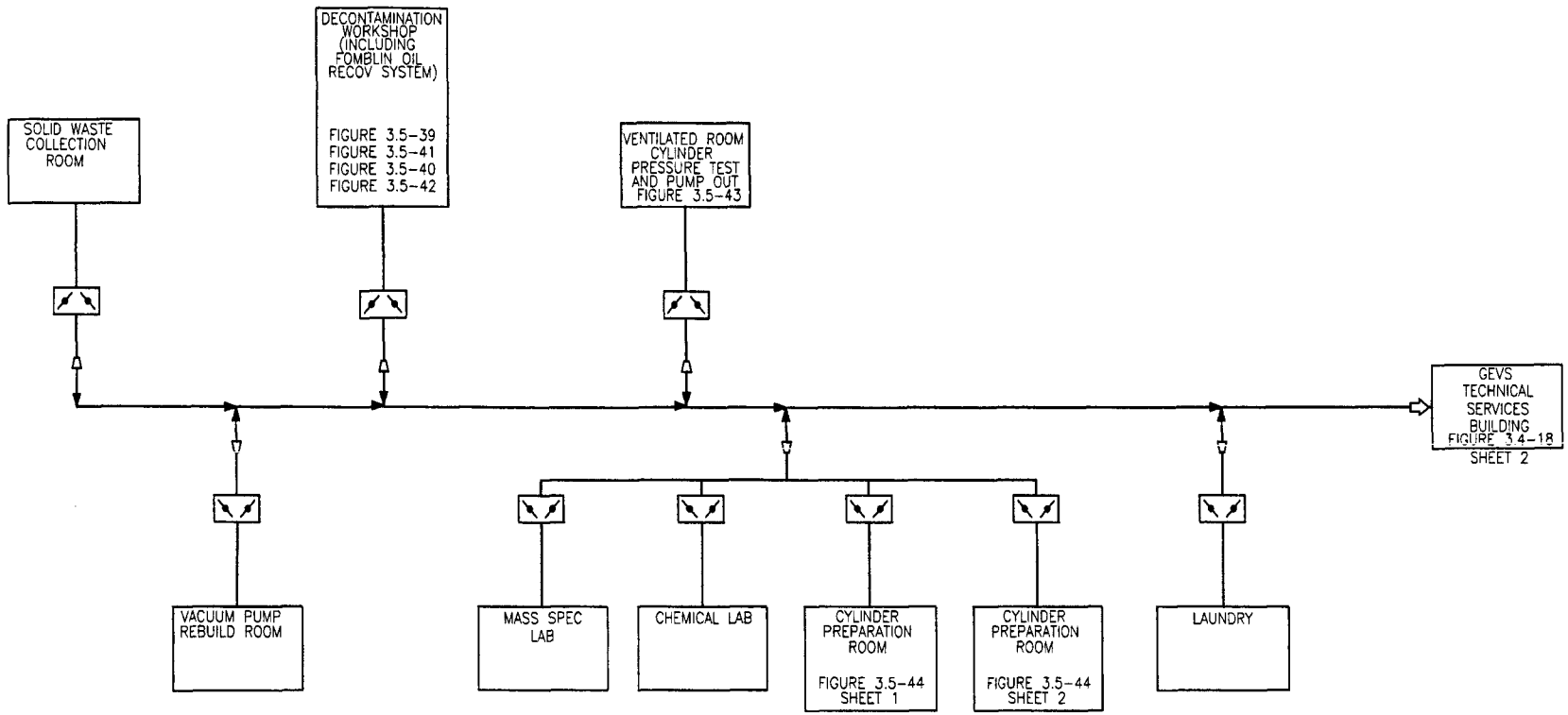
REFERENCE NUMBER
0664-M-1500

FIGURE 3.4-17

PROCESS FL[illegible]GRAM
GASEOUS EFFL[illegible] SYSTEM
SEPARATIO[illegible]NG

REVISION DATE: [illegible]ER 2003



SHEET 1 OF 2

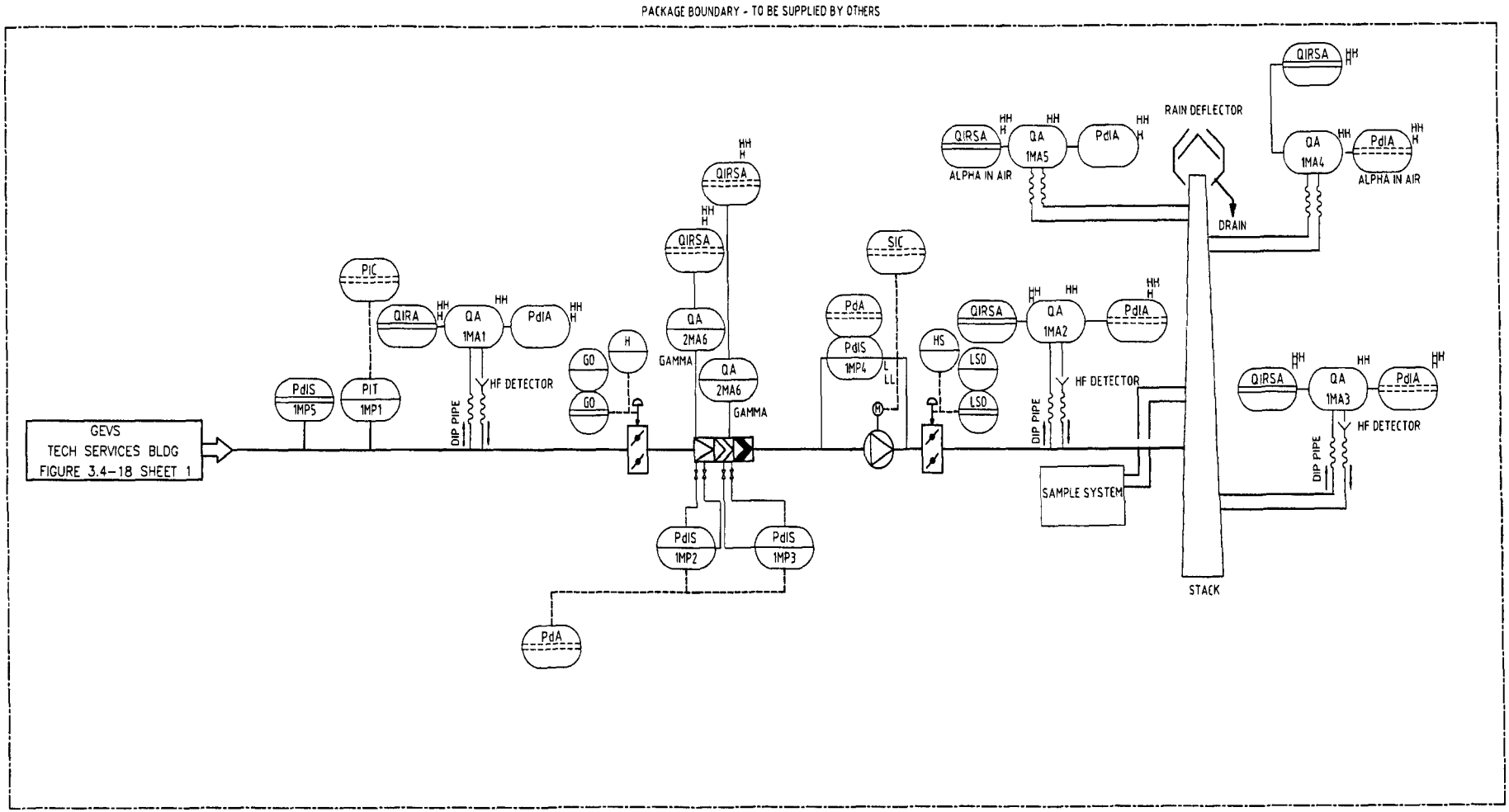
LOCKWOOD GREENE
ENGINEERING & CONSTRUCTION

REFERENCE NUMBER
0666-M-1100

FIGURE 3.4-18

PROCESS FLOW DIAGRAM
GASEOUS EFFLUENT VENT SYSTEM
TECHNICAL SERVICES BUILDING

REVISION DATE: DECEMBER 2003



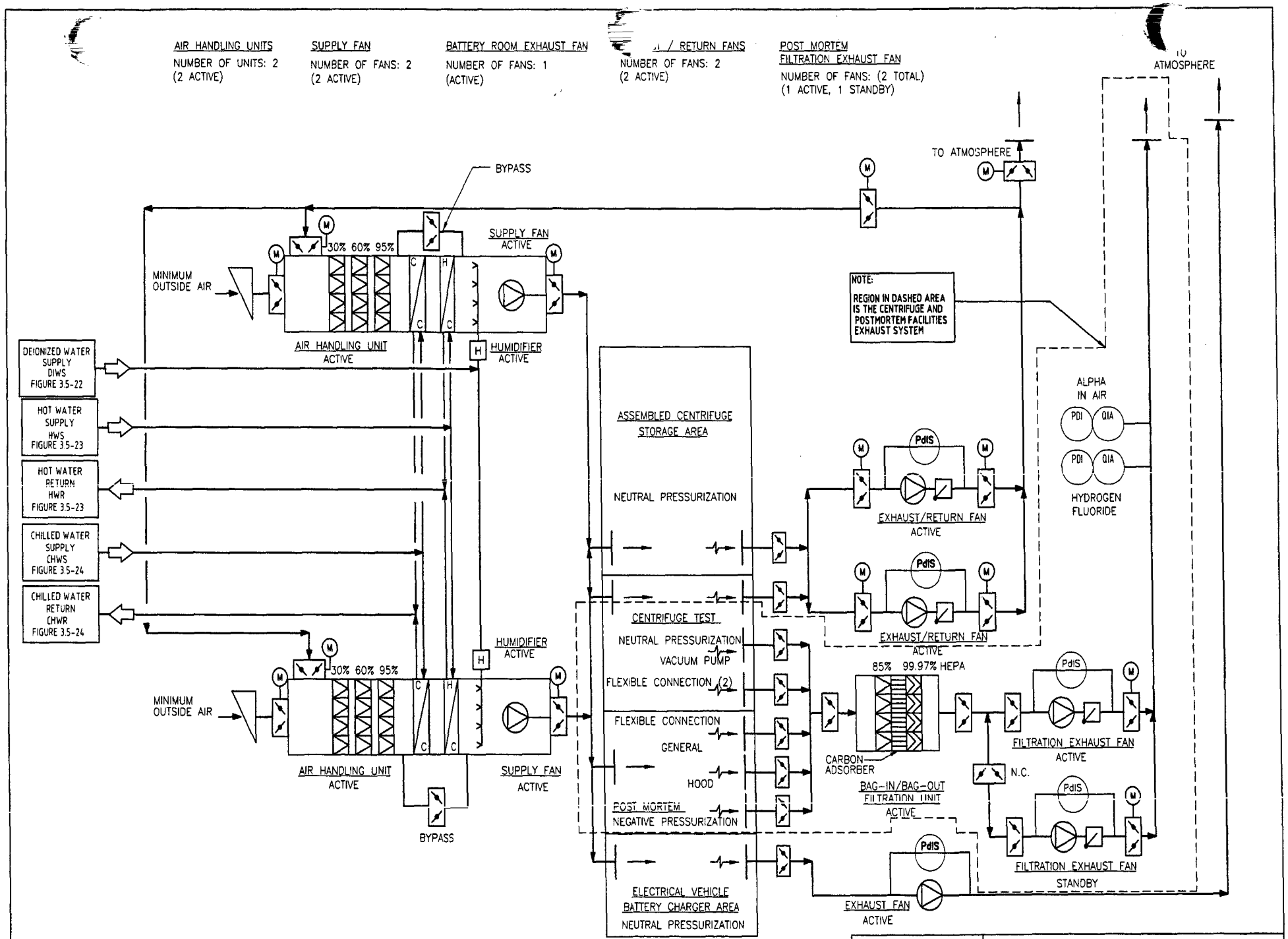
SHEET 2 OF 2

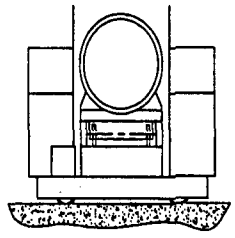
LOCKWOOD GREENE
ENGINEERING & CONSTRUCTION

REFERENCE NUMBER
0666-M-1500

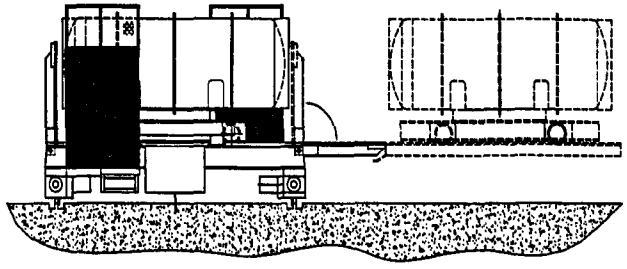
FIGURE 3.4-18

GASEOUS EFFLU[illegible] SYSTEM
TECHNICAL SE[illegible]UILDING
REVISION DATE: D[illegible]ER 2003

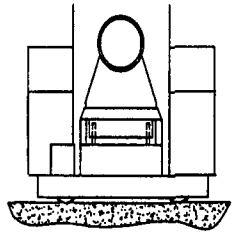

AIR HANDLING UNITS
NUMBER OF UNITS: 2
(2 ACTIVE)
SUPPLY FAN
NUMBER OF FANS: 2
(2 ACTIVE)
BATTERY ROOM EXHAUST FAN
NUMBER OF FANS: 1
(ACTIVE)
/ RETURN FANS
NUMBER OF FANS: 2
(2 ACTIVE)
POST MORTEM
FILTRATION EXHAUST FAN
NUMBER OF FANS: (2 TOTAL)
(1 ACTIVE, 1 STANDBY)
TO ATMOSPHERE
TO ATMOSPHERE
BYPASS
SUPPLY FAN
ACTIVE
30% 60% 95%
MINIMUM
OUTSIDE AIR
AIR HANDLING UNIT
ACTIVE
HUMIDIFIER
ACTIVE
NOTE:
REGION IN DASHED AREA IS THE CENTRIFUGE AND POSTMORTEM FACILITIES EXHAUST SYSTEM
DEIONIZED WATER SUPPLY DIWS FIGURE 3.5-22
HOT WATER SUPPLY HWS FIGURE 3.5-23
HOT WATER RETURN HWR FIGURE 3.5-23
CHILLED WATER SUPPLY CHWS FIGURE 3.5-24
CHILLED WATER RETURN CHWR FIGURE 3.5-24
ASSEMBLED CENTRIFUGE STORAGE AREA
NEUTRAL PRESSURIZATION
CENTRIFUGE TEST
NEUTRAL PRESSURIZATION
VACUUM PUMP
FLEXIBLE CONNECTION (2)
FLEXIBLE CONNECTION
GENERAL
HOOD
POST MORTEM
NEGATIVE PRESSURIZATION
ELECTRICAL VEHICLE
BATTERY CHARGER AREA
NEUTRAL PRESSURIZATION
ALPHA
IN AIR
PDI
QIA
HYDROGEN
FLUORIDE
PdIS
EXHAUST/RETURN FAN
ACTIVE
85% 99.97% HEPA
CARBON ADSORBER
BAG-IN/BAG-OUT
FILTRATION UNIT
ACTIVE
N.C.
FILTRATION EXHAUST FAN
ACTIVE
FILTRATION EXHAUST FAN
STANDBY
EXHAUST FAN
ACTIVE
LOCKWOOD GREENE
ENGINEERING & CONSTRUCTION
REFERENCE NUMBER
1300-H-1003
FIGURE 3.4-19
PROCESS FLOW DIAGRAM
CENTRIFUGE TEST AND POST MORTEM FACILITIES
EXHAUST FILTRATION SYSTEM
REVISION DATE: DECEMBER 2003



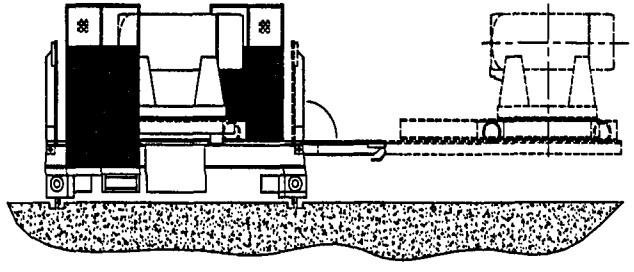
END VIEW
(WITH 48" CYLINDER)



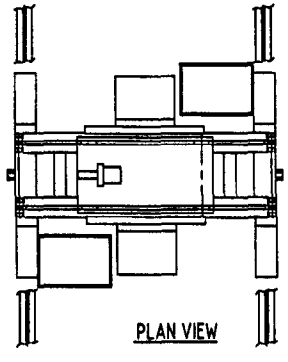
SIDE ELEVATION
(WITH 48" CYLINDER)



END VIEW
(WITH 30" CYLINDER)



SIDE ELEVATION
(WITH 30" CYLINDER)



PLAN VIEW

REFERENCE NUMBER
0UC136325

FIGURE 3.4-20
RAIL TRANS[illegible]
EQUIPMENT

REVISION DATE: DECEMBER [illegible]