Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

FEB 29 2000

~~CERTIFIED MAIL - RETURN RECEIPT REQUESTED~~ HAND-DELIVERED

Mr. John E. Kieling
RCRA Permits Management Program
Hazardous & Radioactive Materials Bureau
New Mexico Environment Department
2044 Galisteo St., Building A
P.O. Box 26110
Santa Fe, New Mexico 87505

Dear Mr. Kieling:

Subject: Permit Modification Request, Los Alamos National Laboratory (LANL)
Hazardous Waste Facility Permit No. NM0890010515-1

On Friday, February 25, 2000, University of California (UC or University) provided Department of Energy (DOE) the enclosed information requesting the addition of a vitrification unit (a treatment unit) and two vitrification unit slab tanks (a tank system) to the permit. The vitrification unit and associated tank system will be located at Technical Area (TA) 55 and will be used to store (prior to treatment) and treat mixed transuranic waste generated at TA-55. These documents were prepared by UC pursuant to the contract between DOE and UC for the University to conduct operations at LANL. The purpose of this letter is to request that the New Mexico Environment Department (NMED) review and approve the information as provided.

The following information is a summary of the information to be included in the permit modification request. Each of the segments below have been prepared to be inserted into the existing permit after NMED approval:

- Proposed Permit Module for the Technical Area 55 Vitrification Unit
- Proposed Permit Module for the Technical Area 55 Vitrification Unit Slab Tanks
- Figure – Location of the Vitrification Unit and Vitrification Unit Slab Tanks at Technical Area (TA) 55
- Attachment A – Waste Analysis Plan
- Attachment B – Inspection Plan
- Attachment C – Personnel Training
- Attachment D – Contingency Plan
- Attachment E.1 – Closure Plan for the Technical Area 55 Vitrification Unit
- Attachment E.2 – Closure Plan for the Technical Area 55 Vitrification Unit Slab Tanks

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- Attachment F – Container Management
- Attachment G – Authorized Wastes
- Certification

The supplemental information is provided in accordance with the requirements of 20 NMAC 4.1, Subparts V and IX [January 1, 1997]. The supplemental information is bound separately and is entitled "Supplemental Information Document for the Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request." Specifically, the supplemental information document contains the following information for the vitrification unit (a Subpart X miscellaneous unit) and the vitrification unit slab tanks (a tank system):

- Facility Description
- General Facility Operations and Waste Management Practices
- Design, Construction, Materials, and Operation for the Vitrification Unit and the Vitrification Unit Slab Tanks
- Demonstration of Treatment Effectiveness for the Vitrification Unit
- Environmental Performance Standards for the Vitrification Unit
- Installation, Testing, and Certification for the Vitrification Unit Slab Tanks
- Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks
- Secondary Containment
- Special Requirements for Ignitable, Reactive, and Incompatible Waste
- Air Emission Standards for Equipment Leaks and Organic Air Emissions
- Record Keeping Requirements
- Corrective Action for Solid Waste Management Units
- Other Federal Laws

If you should have any questions or comments concerning this permit modification request or the supplemental information document, please contact Jody Plum of my staff at (505) 665-5042 or Jack Ellvinger, UC, at (505) 667-0633.

Sincerely,

for: David A. Gurulé, P.E.
Area Manager

LAAME:4JP-012

Enclosures

Document:	**Permit Modification Request TA-55 Vitrification Unit and Vitrification Unit Slab Tanks**
Revision No.:	**0.0**
Date:	**February 2000**

Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request

Prepared by:

Los Alamos National Laboratory
Hazardous and Solid Waste Group (ESH-19)
Los Alamos, New Mexico 87545

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Attachment A Waste Analysis Plan

Attachment B Inspection Plan

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Attachment E.1 Closure Plan for the Technical Area 55 Vitrification Unit

Attachment E.2 Closure Plan for the Technical Area 55 Vitrification Unit Slab Tanks

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Attachment G Authorized Wastes

Certification

PROPOSED HAZARDOUS WASTE FACILITY
MODIFIED PERMIT SUMMARY
FOR THE
TECHNICAL AREA 55 VITRIFICATION UNIT AND VITRIFICATION UNIT SLAB TANKS

Module/Attachment	Section	Modification to Permit
Request for Permit Modification	--	DOE Transmittal Letter/Request for Permit Modification
Module	--	Provided Proposed Permit Module for the Vitrification Unit.
Module	--	Provided Proposed Permit Module for the Vitrification Unit Slab Tanks.
Figure	--	Provided figure to show location of the Vitrification Unit and the Vitrification Unit Slab Tanks.
Attachment A	A	Provided Vitrification Unit and Vitrification Unit Slab Tanks Waste Analysis Plan.
Attachment B	B	Provided Vitrification Unit and Vitrification Unit Slab Tank Inspection Plan as supplement to the "Inspection Plan" provided in the Los Alamos National Laboratory Permit Modification Request, dated November 19, 1999.
Attachment C	C	Provided Vitrification Unit and Vitrification Unit Slab Tank Personnel Training as supplement to the "Personnel Training Plan" provided in the Los Alamos National Laboratory Permit Modification Request, dated November 19, 1999.
Attachment D	D	Provided Vitrification Unit and Vitrification Unit Slab Tank Contingency Plan as supplement to the "Contingency Plan" provided in the Los Alamos National Laboratory Permit Modification Request, dated November 19, 1999.
Attachment E.1	E	Provided Vitrification Unit Closure Plan.
Attachment E.2	E	Provided Vitrification Unit Slab Tanks Closure Plan.
Attachment F	F	Provided statement of Container Management nonapplicability.
Attachment G	G	Provided table of authorized waste for the Vitrification Unit and Vitrification Unit Slab Tanks.
Certification	--	Provided certification page.

Proposed Permit Module for the Technical Area 55 Vitrification Unit

A. TECHNICAL AREA 55 VITRIFICATION UNIT

Mixed transuranic (TRU) waste may be treated in the vitrification unit located on the first floor of Building 4 in Technical Area 55.

B. AUTHORIZED WASTES

1. Identification. Only wastes identified in Permit Attachment G with the process code "T04" in Column D(1), "Process Codes," shall be treated.
2. Quantities. The cumulative quantity of wastes treated shall not exceed the quantity indicated in Permit Attachment G, Column B, "Estimated Annual Quantity of Waste."
3. Additions to the List of Treated Wastes. The Permittee shall apply for a permit modification in accordance with the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.41 or 270.42, revised January 1, 1997 [1-1-97], before treating wastes not identified in this permit module.
4. Special Limitations. The limitations in Permit Attachment G, Column D(2), "Process Description," shall apply to choice of treatment unit.

C. DESIGN OF TREATMENT UNIT

The vitrification unit shall consist of a glass frit feed system, a melter system, a glass/waste handling system, an off-gas control system, a glovebox, associated piping, and support structures. Secondary containment for the vitrification unit shall be provided by Room 434A, which has sufficient capacity to contain 100 percent of the volume of the largest waste container or tank within Room 434A. The floor shall be free of gaps and cracks and be coated with a chemical and temperature resistant epoxy primer and epoxy paint.

D. OPERATING REQUIREMENTS

The vitrification unit shall be operated in accordance with the requirements of this permit module.

1. The process monitoring instrumentation shall be checked for proper operation before treatment begins. No treatment shall be started if monitoring instruments are not functioning properly.
2. Waste shall be sampled and analyzed in accordance with Permit Attachment A.
3. No more than 50 liters per hour of mixed TRU waste in addition to glass frit shall be treated. The wastes shall be limited to the appropriate quantities based on the results of the analyses and the estimated quantity of glass frit required to treat the waste.
4. The off-gas system shall be operational whenever the vitrification unit is treating wastes.
5. The molten mass shall be maintained at a minimum temperature of 1000°C for a minimum soak time of 2 hours.

E. INSPECTIONS

1. Inspection Plan. The Permittee shall inspect the vitrification unit in accordance with Permit Attachment B and the requirements of this permit module.
2. Spill Kits. The type, presence, location, and quantity of spill kits shall initially be verified, a tamper proof seal shall be placed on the spill kits, and the tamper proof seal shall be inspected weekly.
3. Accumulated Liquids. Accumulated liquids discovered in the secondary containment structure shall be removed within 24 hours of discovery.
4. Repairs to Secondary Containment Structure. Cracks and/or gaps in the secondary containment structure discovered during an inspection shall be repaired within 14 calendar days of discovery. Cracks determined to be minor and not adversely affecting containment integrity shall be logged and delay of repairs justified. Repair of minor cracks may be deferred until regularly scheduled maintenance.
5. Warning Signs. The legibility and condition of warning signs shall be included in the weekly inspection. Missing or illegible signs shall be promptly replaced within 24 hours of discovery.
   a. Signs shall be located at the entrance to the room in which the vitrification unit is located.
   b. Signs shall say "Danger, Unauthorized Personnel Keep Out."
   c. Signs shall be in English and Spanish.

F. CLOSURE

The Permittee shall close the vitrification unit is accordance with Permit Attachment E.1 and in a manner that will ensure protection of human health and environment, in accordance with 20 NMAC 4.1, Subpart V, 264.601 [1-1-97].

Proposed Permit Module for the Technical Area 55 Vitrification Unit Slab Tanks

A. TECHNICAL AREA 55 VITRIFICATION UNIT SLAB TANKS

Mixed transuranic (TRU) waste may be stored in the vitrification unit slab tanks located on the first floor of Building 4 in Technical Area 55.

B. AUTHORIZED WASTES

1. Identification. Only wastes identified in Permit Attachment G with the process code "S02" in Column D(1), "Process Codes," shall be stored.
2. Quantities. No more than 250 liters of liquid waste shall be stored at any one time.

C. TANK DESCRIPTION

1. Capacity. Each tank shall have a capacity of approximately 125 liters.
2. Type. Each tank shall be constructed of 316L stainless steel.
3. Quantity of Tanks. Two.
4. Condition. If a tank holding mixed TRU waste is not in good condition (e.g., severe rusting, structural defects) or if it begins to leak, the Permittee shall transfer the mixed TRU waste from such tanks to a tank or container that is in good condition or otherwise manage the waste in compliance with the conditions of this permit.
5. Compatibility of Waste with Tanks. The Permittee shall assure, as required by the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, 264.199, revised January 1, 1997 [1-1-97], that the ability of the tanks to contain the mixed TRU waste is not impaired.

D. CONTAINMENT

Secondary containment for the vitrification unit slab tanks shall be provided by Room 434A, which has sufficient capacity to contain 100 percent of the volume of the largest container or tank within Room 434A. The floor shall be free of cracks and be coated with a chemical and temperature resistant epoxy primer and epoxy paint. The Permittee shall maintain the secondary containment system for the tanks in accordance with the requirements of 20 NMAC 4.1, Subpart V, 264.193 [1-1-97].

E. IGNITABLE OR REACTIVE WASTE

The Permittee shall not locate tanks holding ignitable or reactive waste within 15 meters (50 feet) of the facility property line. The provisions of 20 NMAC 4.1, Subpart V, 264.198 [1-1-97], will be followed.

F. INCOMPATIBLE WASTES

The Permittee shall manage incompatible waste or incompatible wastes and materials in accordance with the requirements of 20 NMAC 4.1, Subpart V, 264.199 [1-1-97].

G. CLOSURE

The Permittee shall close the vitrification unit slab tanks is accordance with Permit Attachment E.2 and in a manner that will ensure protection of human health and environment, in accordance with 20 NMAC 4.1, Subpart V, 264.197 [1-1-97].

H. INSPECTIONS

1. Inspection Plan. The Permittee shall inspect the vitrification unit slab tanks in accordance with Permit Attachment B and the requirements of this permit module.
2. Spill Kits. The type, presence, location and quantity of spill kits shall initially be verified, a tamper proof seal shall be placed on the spill kits, and the tamper proof seal shall be inspected weekly.
3. Accumulated Liquids. In accordance with 20 NMAC 4.1, Subpart V, 264.193(c)(4) [1-1-97], accumulated liquids discovered in the secondary containment structure shall be removed within 24 hours of discovery.
4. Repairs to Secondary Containment Structure. Cracks and/or gaps in the secondary containment structure discovered during an inspection shall be repaired within 14 calendar days of discovery. Cracks determined to be minor and not adversely affecting containment integrity shall be logged and delay of repairs justified. Repair of minor cracks may be deferred until regularly scheduled maintenance.
5. Warning Signs. The legibility and condition of warning signs shall be included in the weekly inspection. Missing or illegible signs shall be promptly replaced within 24 hours of discovery.
   a. Signs shall be located at the entrance to the room in which vitrification unit slab tanks are located.
   b. Signs shall say "Danger, Unauthorized Personnel Keep Out."
   c. Signs shall be in English and Spanish.

I. RESPONSE TO LEAKS OR SPILLS

The Permittee shall follow the requirements of 20 NMAC 4.1, Subpart V, 264.196 [1-1-97], in response to a leak or a spill.

J. CERTIFICATION OF REPAIRS

All major repairs to any tanks or associated plumbing shall be certified in accordance with 20 NMAC 4.1, Subpart V, 264.196(f) [1-1-97], prior to being placed back in service.

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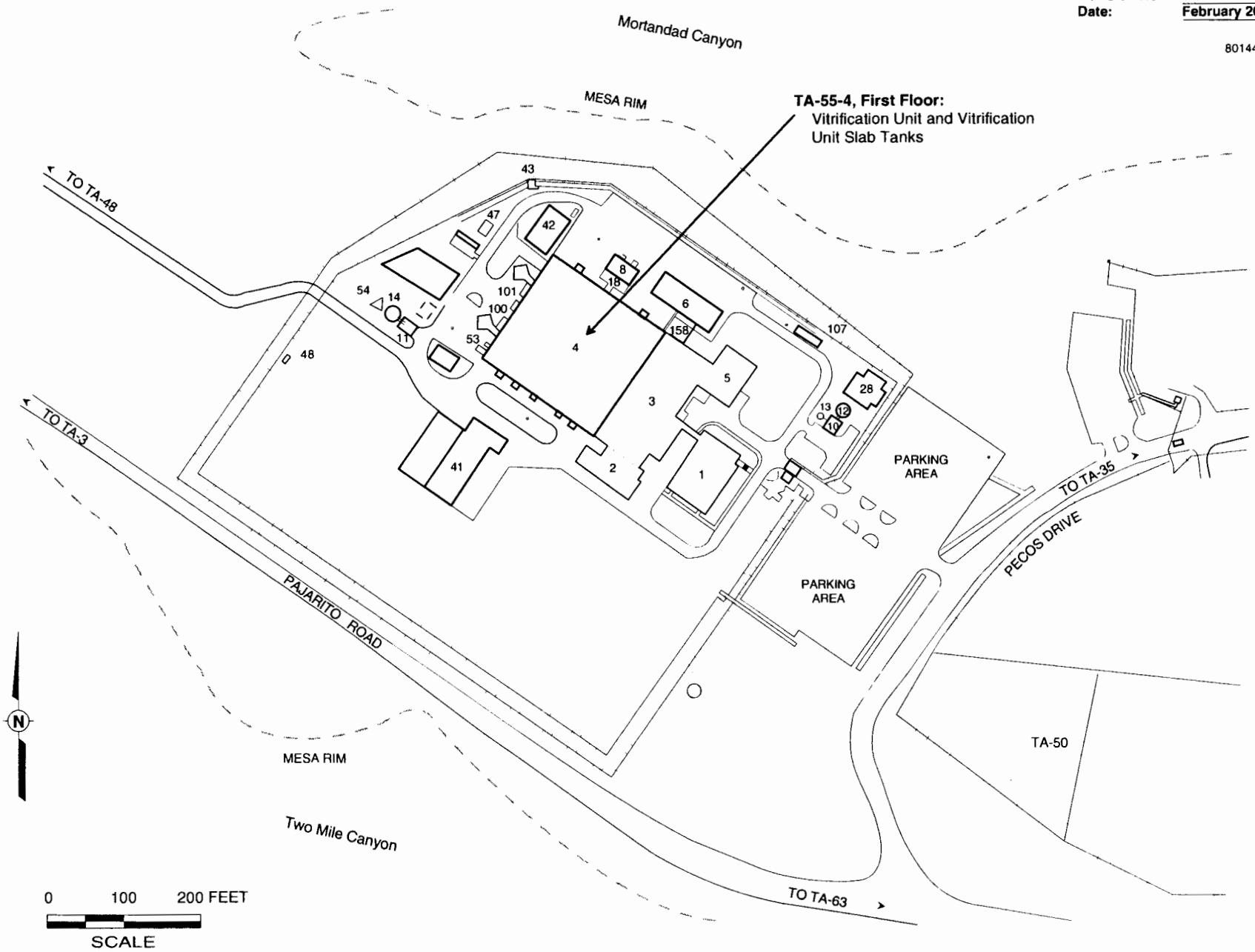

Figure
Location of the Vitrification Unit and Vitrification Unit Slab Tanks at Technical Area (TA) 55

WASTE ANALYSIS PLAN

PERMIT ATTACHMENT A
NM0890010515-1

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LIST OF ABBREVIATIONS/ACRONYMS

40 CFR	Title 40 of the Code of Federal Regulations
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LANL	Los Alamos National Laboratory
LDR	land disposal restrictions
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
NMED	New Mexico Environment Department
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
SVOC	semivolatile organic compound
SW-846	EPA's "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods"
TA	technical area
TC	toxicity characteristic
TRU	transuranic
TWCP	Transuranic Waste Certification Plan
VOC	volatile organic compound
WAP	waste analysis plan
WIPP	Waste Isolation Pilot Plant

ATTACHMENT A
WASTE ANALYSIS PLAN

This waste analysis plan (WAP) presents information on the chemical and physical nature of evaporator bottoms solutions, a mixed transuranic (TRU) waste, to be stored in the vitrification unit slab tanks and treated in the vitrification unit to be located at Technical Area (TA) 55 at Los Alamos National Laboratory (LANL), and the resulting treated vitrified waste. It has been prepared to meet the requirements set forth in the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, 264.13, revised January 1, 1997 [1-1-97]. Additional waste analysis requirements are specified in 20 NMAC 4.1, Subpart IX, 270.14(b) and 20 NMAC 4.1, Subpart VIII, 268.7 [1-1-97]. The content of this WAP follows the guidance provided in "Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Wastes, A Guidance Manual" (U.S. Environmental Protection Agency [EPA], 1994). It is organized as follows:

Section A.1 Facility Description: Includes a general description of the vitrification unit slab tanks and vitrification unit.

Section A.2 Description of Waste: Includes a general description of the waste stream stored in the vitrification unit slab tanks and treated in the vitrification unit and the waste resulting from treatment in the vitrification unit.

Section A.3 Waste Analysis Parameters: Includes a discussion of the proposed analytical parameters and methods used by LANL and the criteria/rationale for the parameter selection.

Section A.4 Characterization Procedures: Includes the characterization approach (e.g., acceptable knowledge, sampling and analysis) for the waste to be stored in the vitrification unit slab tanks and the waste resulting from treatment in the vitrification unit.

Section A.5 Special Procedural Requirements: Includes a discussion of the procedures in place for ignitable, reactive, and incompatible wastes; procedures to ensure compliance with land disposal restrictions (LDR); and procedures to ensure compliance with Subpart CC requirements in Title 40 of the Code of Federal Regulations (40 CFR), Part 264.

Section A.6 References.

A.1 FACILITY DESCRIPTION [20 NMAC 4.1, Subpart V, 270.14(b)(1)]

The vitrification unit will be a Subpart X miscellaneous waste management unit pursuant to 20 NMAC 4.1, Subpart V, Subpart X, and will be used to vitrify or stabilize evaporator bottoms solutions, a mixed TRU waste hereafter referred to as evaporator bottoms, into a solid glass matrix. The

vitrification process is designed to treat the evaporator bottoms and remove these hazardous characteristics. The vitrification unit slab tanks will be regulated Subpart J tank system units that will store the evaporator bottoms prior to treatment in the vitrification unit. The vitrification unit and vitrification unit slab tanks will be located at TA-55, Building 4, Room 434A. The vitrification unit will consist of a single batch in-can melter, a glass frit feed system, a glass/waste handling system to cool and move the glass-filled cans, an off-gas system, a glovebox, associated support structures, and associated piping. The vitrification unit slab tanks will consist of two 125-liter tanks, which will serve as batch feed tanks for the vitrification unit.

A.2 DESCRIPTION OF WASTE

TRU waste is defined in U.S. Department of Energy (DOE) Order 5820.2A, "Radioactive Waste Management" (DOE, 1988), as follows: "Without regard to source or form, waste that is contaminated with alpha emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram at the time of assay and has atomic numbers greater than 92. Heads of Field Elements can determine that other alpha contaminated waste, peculiar to a specific site, must be managed as TRU waste." Mixed TRU waste contains both a hazardous waste component and a TRU waste component. For mixed TRU waste, this WAP addresses only the hazardous component.

The mixed TRU waste that will be treated and stored in the vitrification unit and vitrification unit slab tanks is evaporator bottoms. It is generated primarily from research and development activities and processing and recovery operations at TA-55. This waste consists of concentrated nitric acid saturated with salts and metals. The evaporator bottoms typically exhibit the hazardous characteristics of corrosivity and toxicity for metals (including arsenic, barium, cadmium, chromium, lead, mercury, and silver), as defined in 20 NMAC 4.1 Subpart II, 261.22 and 261.24 [1-1-97], respectively. The waste stream will be mixed with glass materials, heated to high temperatures, and immobilized in the vitrification process. The treated vitrified waste will consist of melter cans containing the solidified glass matrix. The treated vitrified waste will be classified as TRU waste and will not exhibit any hazardous characteristics. After vitrification and cooling, the melter can containing the treated vitrified waste will be lowered into a standard 55-gallon drum for "bagout." The 55-gallon drum will contain an inner liner of insulation or padding, which will surround the melter can and keep it from moving within the 55-gallon drum. Table A-1 provides a description of the evaporator bottoms and the treated vitrified waste.

LANL uses matrix parameter codes to define waste characterization groupings for the "Federal Facility Compliance Order (Los Alamos National Laboratory)" (New Mexico Environment Department [NMED], 1995). These codes are based on the physical and chemical form of the waste. Complete descriptions of the matrix parameter codes are available in "DOE Waste Treatability Groups Guidance" (DOE, 1995). The evaporator bottoms stored in the vitrification unit slab tanks and treated in the vitrification unit will be identified by matrix parameter code L1000. The treated vitrified waste generated by the vitrification unit will be identified by matrix parameter code S3000. A general description of the matrix parameter codes are provided below:

- *Matrix Parameter Code L1000, Aqueous Liquids/Slurries*: defined as aqueous liquids and slurries that meet the EPA LDR criteria for wastewaters (i.e., <1 percent total suspended solids).
- *Matrix Parameter Code S3000, Homogeneous Solids*: defined as solid waste materials, excluding soil/gravel, that do not meet the EPA LDR criteria for classification as debris.

A.3 WASTE ANALYSIS PARAMETERS

A detailed chemical and physical characterization will be performed on the evaporator bottoms and the treated vitrified waste, as required by 20 NMAC 4.1, Subpart V, 264.13, and 20 NMAC 4.1, Subpart IX, 270.14(b)(2) [1-1-97]. Waste analysis parameters have been selected to ensure that the characterization documentation will contain all information necessary to properly treat the waste in accordance with Resource Conservation and Recovery Act (RCRA) general facility standards and LDR requirements.

A.3.1 Proposed Analytical Parameters and Methods [20 NMAC 4.1, Subpart V, 264.13(b)(1) and (2); 20 NMAC 4.1, Subpart IX, 270.14(b)(2)]

Analytical parameters and characterization methods to be used for the evaporator bottoms stored in the vitrification unit slab tanks and treated in the vitrification unit and the treated vitrified waste generated by the vitrification unit are summarized in Tables A-2 and A-3. Some or all of the following parameters will be used to determine the regulatory status:

- Acceptable knowledge
- pH characterization
- Sampling and analysis to determine the presence and concentrations of RCRA-regulated metals

LANL's use of acceptable knowledge procedures for mixed TRU waste characterization is based on and described in Section A.2.3.2 of the "Waste Analysis Plan for Transuranic Mixed Waste," as contained in the RCRA Permit Modification Request for Technical Area 50 and Technical Area 54 West (LANL, 1995), and approved as a Class III permit modification by the NMED on February 28, 1997. LANL's use of acceptable knowledge is also based on U.S. Environmental Protection Agency guidance (EPA, 1994).

A.3.2 Criteria and Rationale for Parameter Selection [20 NMAC 4.1, Subpart V, 264.13(b)(1)]

The mixed TRU waste characterization procedures employed by LANL utilize acceptable knowledge where possible, as these waste streams may contain levels of radioactivity that pose health and safety risks if physically sampled and analyzed. Characterization of the evaporator bottoms to be treated in the vitrification unit is based on knowledge of the raw materials and physical/chemical processes of the waste-generating activities. This information may be supported by supplemental analytical results. Additional characterization procedures for the evaporator bottoms and for the treated vitrified waste will be implemented, as needed, to meet the requirements of the final Waste Isolation Pilot Plant (WIPP) WAP permit conditions (NMED, 1999). The specific rationale for parameter selection of the initial and final waste streams is identified in Table A-2.

A.4 CHARACTERIZATION PROCEDURES

The approach to characterization of the evaporator bottoms and the treated vitrified waste is based on acceptable knowledge and the chemical, physical, and radiological nature of the waste streams. Characterization procedures require that each waste generator provide documented information on the waste stream. This is accomplished by using acceptable knowledge and/or sampling and analysis. The completion of characterization documentation allows for the assignment of EPA Hazardous Waste Numbers and the proper management of the waste. All waste generators must certify, based on their knowledge of the waste, that the information included in the characterization documentation is complete and accurate.

A.4.1 Characterization Procedures for the Mixed TRU Waste to Be Treated [20 NMAC 4.1, Subpart V, 264.13(b)(2) and (3); 20 NMAC 4.1, Subpart IX, 270.14(b)(2)]

A detailed chemical and physical characterization of the evaporator bottoms will be performed. Process knowledge and/or chemical analytical data will be utilized to adequately characterize the waste stream. The evaporator bottoms generated at TA-55 and stored in the vitrification unit slab

tanks will consist of aqueous solutions. Based on acceptable knowledge, this waste stream does not contain any volatile organic compounds (VOC) or semivolatile organic compounds (SVOC). This waste stream will be sampled and analyzed for pH and toxicity characteristic (TC) metals to establish a baseline. Parameters and analytical methods for specific hazardous constituents are presented in Table A-3. Additional characterization to meet WIPP certification procedures will be implemented to meet the requirements of the WIPP WAP permit conditions.

To ensure the collection of a representative sample, the sample will be collected and handled in a manner that preserves its original physical form and composition and prevents contamination or changes in concentration of the parameters to be analyzed. The samples will typically be collected using a glass tube or composite liquid waste sampler, in accordance with "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" *SW-846* (EPA, 1986) or other approved methods.

To ensure that proper procedures and considerations for sample collection and preservation, quality assurance (QA) and quality control (QC), and occupational safety and health are followed, personnel involved in sampling and analysis of mixed TRU waste solutions at TA-55 will comply with LANL-specific protocol consistent with *SW-846*.

A.4.2 Characterization Procedures for the Treated Waste [20 NMAC 4.1, Subpart V, 264.13(b)(2) and (3); 20 NMAC 4.1, Subpart IX, 270.14(b)(2)]

The treated vitrified waste will be shipped to WIPP for disposal. Therefore, the treated vitrified waste will be characterized in accordance with the "Los Alamos National Laboratory Transuranic Waste Certification Plan" (TWCP) (LANL, 1999), which incorporates the certification requirements of the WIPP WAP for waste to be shipped to WIPP. The TWCP establishes the programmatic framework and requirements within which waste generators must operate to ensure that their wastes can be certified as meeting the sampling, characterization, and packaging requirements of the WIPP WAP. The TWCP characterization procedure for the treated vitrified waste also meets the RCRA waste analysis requirements of 20 NMAC 4.1, Subpart V, 264.13(a) [1-1-97].

Process knowledge and chemical analytical data will be utilized to characterize the treated vitrified waste. Based on the operating temperatures of the vitrification process, the treated vitrified waste will not contain VOCs or SVOCs. The treated vitrified waste stream will be analyzed for TC metals

utilizing the Toxicity Characteristic Leaching Procedure to confirm successful treatment and to confirm that the waste stream is no longer RCRA-regulated. The TC metals to be analyzed for include arsenic, barium, cadmium, chromium, lead, and silver. To ensure the collection of representative samples, each sample will be collected and handled in a manner that preserves its original physical form and composition and prevents contamination or changes in concentration of the parameters to be analyzed. Sample collection of the treated vitrified waste will be in accordance with the TWCP, the WIPP WAP permit conditions, and LANL-specific protocol consistent with *SW-846*.

A.4.3 Sample Handling, Preservation, and Storage

Table A-4 presents *SW-846* requirements regarding sample containers, preservation techniques, and holding times associated with sample collection. Sampling personnel will adhere to these requirements to ensure that sampling and analysis meet quality objectives for data.

A.4.4 Analytical Laboratory Selection and Analytical Methods [20 NMAC 4.1, Subpart V, 264.13(b)(2)]

Analytical laboratories at LANL and/or approved subcontractor laboratories will perform the detailed qualitative and quantitative chemical analyses specified in Table A-3 of this WAP. These laboratories must have:

- The capability of handling radioactive waste samples
- A documented comprehensive QA/QC program
- Technical analytical expertise
- A document control/records management plan
- The capability to perform data reduction, validation, and reporting.

The selection and development of analytical testing methods for the evaporator bottoms and the treated vitrified waste were based on the following considerations:

- The physical form of the waste
- Analytes of interest
- Information requirements (e.g., verify compliance with LDR treatment standards, waste classification)

Collectively, these factors contributed to the selection of the analytical methods specified in Table A-3. Qualified analytical laboratories at LANL and/or approved subcontractor laboratories that meet the above criteria will analyze the waste samples for RCRA-regulated hazardous constituents (metals) and characteristics according to *SW-846* or documented and approved equivalent methods.

A.4.5 Reevaluation Frequencies [20 NMAC 4.1, Subpart V, 264.13(a)(3) and 264.13(b)(4)]
Reevaluation of the initial characterization information may be performed to verify the accuracy of the initial waste characterization, to verify that applicable treatment standards have been met, when there is a change in a waste-generating process, when the generator requests a review, or when analytical results indicates a change in the waste stream.

Routinely generated waste streams will be reevaluated annually to verify that they have not changed. This annual reevaluation will be accomplished through review and recertification of applicable waste characterization documentation. Any information that indicates a change in the process that generates the waste or may affect the waste shall cause the waste to be recharacterized no later than the next time the waste is generated.

A.5 SPECIAL PROCEDURAL REQUIREMENTS

Waste management requirements specific to ignitable, reactive, and incompatible waste, as well as for compliance with LDR and 40 CFR, Part 264, Subpart CC regulations, are described below.

A.5.1 Ignitable, Reactive, and Incompatible Wastes [20 NMAC 4.1, Subpart V, 264.13(b)(6)]
The vitrification unit slab tanks will not store ignitable, reactive, or incompatible waste. The vitrification unit will not treat nor will the treatment process produce ignitable, reactive, or incompatible wastes.

A.5.2 LDR Requirements [20 NMAC 4.1, Subpart VIII, 268.7]
The treated vitrified waste is destined for disposal at WIPP and, thus, it is expected that the treated vitrified waste will not be subject to the LDR treatment requirements for land disposal. Under Public Law 104-201, effective September 23, 1996, WIPP is exempt from the provisions of LDR.

A.5.3 Organic Air Emission Standards [20 NMAC 4.1, 264.200; 40 CFR, Part 264, Subpart CC]

Tanks that store only mixed waste are not subject to the requirements of 40 CFR, Part 264, Subpart CC, "Air Emission Standards for Tanks, Surface Impoundments, and Containers." Only mixed waste will be stored in the vitrification unit slab tanks; therefore, the vitrification unit slab tanks are not subject to 40 CFR, Part 264, Subpart CC.

A.6 REFERENCES

DOE, 1995, "DOE Waste Treatability Groups Guidance," Revision 0.0, U.S. Department of Energy, Idaho Operations Office.

DOE, 1988, "Radioactive Waste Management," *DOE Order 5820.2A*, U.S. Department of Energy, Washington, D.C.

EPA, 1994, "Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Wastes, A Guidance Manual," *OSWER 9938.4-03*, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA, 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA SW-846*, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.

LANL, 1995, "RCRA Permit Modification Request, Technical Area 50, Building 1: Rooms 35, 36, and 38/38A Container Storage Areas; Building 69; Waste Characterization, Reduction, and Repackaging Facility, Indoor and Outdoor Container Storage Areas; Technical Area 54 West, Building 38, Radioassay and Nondestructive Testing Facility High Bay, Low Bay, Loading Dock, and Outdoor Container Storage Areas," September 29, 1995, as modified by "Los Alamos National Laboratory TRU Mixed Waste Analysis Plan NOD Response," July 12, 1996, Los Alamos National Laboratory, Los Alamos, New Mexico.

LANL, 1999, "Los Alamos National Laboratory Transuranic Waste Certification Plan," *TWCP-PLAN-0.2.4-001*, R.2, Los Alamos National Laboratory, Los Alamos, New Mexico.

NMED, 1999, "Waste Isolation Pilot Plant, Hazardous Waste Facility Permit," EPA No. NM 4890139088, October 27, 1999, U.S. Department of Energy.

NMED, 1995, "Federal Facility Compliance Order (Los Alamos National Laboratory)" New Mexico Environment Department, Santa Fe, New Mexico.

Table A-1

Description of Wastes Associated with the Vitrification Unit and Vitrification Unit Slab Tanks

Matrix Parameter Code	Waste Description	Waste Generating Activity	Basis for Hazardous Waste Designation	Potential EPA Hazardous Waste Numbers	Potential Hazardous Constituents in the Waste	Regulatory Limits[a] (milligrams per liter)
L1000 – Aqueous Liquids/Slurries	Evaporator Bottoms Solutions, Aqueous Waste	Process residue from evaporator bottoms and other discardable solutions.	Acceptable Knowledge[b]	D002	Nitric acid	NA
				D004	Arsenic	5.0
				D005	Barium hydroxide	100.0
				D006	Cadmium	1.0
				D007	Chromium	5.0
				D008	Lead	5.0
				D009	Mercury	0.2
				D011	Silver	5.0
S3000 – Homogenous Solids	Non-hydrogenous Vitrified Waste in Metal Containers	Process residue from evaporator bottoms and other discardable solutions.	Acceptable Knowledge[b]	D004	Arsenic	5.0
				D005	Barium hydroxide	100.0
				D006	Cadmium	1.0
				D007	Chromium	5.0
				D008	Lead	5.0
				D011	Silver	5.0

[a] A solid waste exhibits the characteristic of toxicity if, using the Toxicity Characteristic Leaching Procedure, Test Method 1311 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C., the extract from a representative sample of the waste contains any of the contaminants listed at a concentration equal to or greater than the respective value given in the New Mexico Administrative Code, Title 20, Chapter 4, Part 1, Subpart II, 261.24, revised January 1, 1997.

[b] Acceptable knowledge is broadly defined as "process knowledge, supplemental waste analysis data, and/or facility records of analysis," U.S. Environmental Protection Agency, 1994, "Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste, A Guidance Manual," *OSWER 9938.4-03*, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA = U.S. Environmental Protection Agency
NA = not applicable

Table A-2

Parameters, Characterization Methods, and Rationale for Parameter Selection

Matrix Parameter[a] Code/Description	Waste Description	Parameters	Characterization Methods	Rationale
L1000 - Aqueous Liquids/Slurries	Evaporator bottoms solutions, aqueous waste	– RCRA-regulated metals and corrosivity	– Acceptable Knowledge[b] – Sampling and Analysis	– Determine toxicity characteristics – Determine concentration of metals
S3000 - Homogeneous Solids	Vitrified evaporator bottoms solutions, solid glass matrix	– RCRA-regulated metals	– Acceptable Knowledge – Sampling and Analysis	– Determine concentration of metals

[a] Information in this column was extracted from the U.S. Department of Energy, 1994, "TRU Waste Characterization Quality Assurance Program Plan," *CAO-94-1010*, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.

[b] Acceptable knowledge is broadly defined as "process knowledge, supplemental waste analysis data, and/or facility records of analysis," U.S. Environmental Protection Agency, 1994, "Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste, A Guidance Manual," *OSWER 9938.4-03*, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

RCRA = Resource Conservation and Recovery Act

Table A-3

Summary of Characterization Methods

Parameter	Method Numbers	Test Methods	Rationale
	L1000 – Aqueous Liquids/Slurries		
Metals in waste: Arsenic Barium Cadmium Chromium Lead Mercury Silver	*SW-846*[a] (1311, 6010B, 7060A[b], 7061A)[a] (1311, 6010B, 7080A[c], 7081[b])[a] (1311, 6010B, 7130[c], 7131A[b])[a] (1311, 6010B, 7190[c], 7191[b])[a] (1311, 6010B, 7420[c], 7421[b])[a] (1311, 7470B, 7471A, 7472[b])[a] (1311, 6010B, 7760A[c], 7761[b])[a] or equivalent methods[d]	Total and/or toxicity characteristic leaching procedure (TCLP) Inductively-coupled plasma atomic emission spectroscopy Atomic absorption Furnace technique Gaseous hydride Direct aspiration Borohydride reduction Manual cold vapor atomic absorption Acceptable knowledge[e]	Determine total and/or TCLP metals concentration in samples
pH	SW-846 (9040B)[a] or equivalent methods[f]	pH electrometric measurement	Determine corrosivity
	S3000 - Homogenous Solids		
Metals in waste: Arsenic Barium Cadmium Chromium Lead Silver	*SW-846*[a] (1311, 6010B, 7060A[b], 7061A)[a] (1311, 6010B, 7080A[c], 7081[b])[a] (1311, 6010B, 7130[c], 7131A[b])[a] (1311, 6010B, 7190[c], 7191[b])[a] (1311, 6010B, 7420[c], 7421[b])[a] (1311, 6010B, 7760A[c], 7761[b])[a] or equivalent methods[d]	Total and/or toxicity characteristic leaching procedure (TCLP) Inductively-coupled plasma atomic emission spectroscopy Atomic absorption Furnace technique Gaseous hydride Direct aspiration Borohydride reduction Acceptable knowledge[e]	Determine total and/or TCLP metals concentration in samples

[a] EPA, 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846* (*SW-846*), Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.
[b] Method being integrated into Method 7000B, per the January 1998 *SW-846* Draft Update IVA.
[c] Method being integrated into Method 7010, per the January 1998 *SW-846* Draft Update IVA.
[d] Equivalent methods, subject to EPA approval, may be substituted.
[e] Acceptable knowledge is broadly defined as "process knowledge, supplemental waste analysis data, and/or facility records of analysis," U.S. Environmental Protection Agency (EPA), 1994, "Waste Analysis at Facilities that Generate, Treat, Store, and Dispose of Hazardous Waste, A Guidance Manual," *OSWER 9938.4-03*, EPA, Office of Solid Waste and Emergency Response, Washington, D.C.

Table A-4

Recommended Sample Containers[a], Preservation Techniques, and Holding Times[b]

Analyte Class and Sample Type	Container	Preservative	Holding Time
Liquid Samples:			
TC Metals	1-L P[c] or G[d]	Add nitric acid to adjust pH to less than 2.	180 days
Arsenic			
Barium			
Cadmium			
Chromium			
Lead			
Silver			
TC Mercury	500-mL P[c] or G[d]	Add nitric acid to adjust pH to less than 2.	28 days
Vitrified Waste:			
TCLP Metals	500-mL WM[e]-P[c] or G[d]		180 days
Arsenic			
Barium			
Cadmium			
Chromium			
Lead			
Silver			

[a] Smaller sample containers may be required due to health and safety concerns associated with potential radiation exposure, transportation requirements, and waste management considerations.
[b] Information primarily from "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, U.S. Environmental Protection Agency, 1986 and all approved updates, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.
[c] P = Polyethylene
[d] G - Glass
[e] WM = Wide-mouth

INSPECTION PLAN

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LIST OF ABBREVIATIONS/ACRONYMS

IRF	Inspection Record Form
LANL	Los Alamos National Laboratory
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
NMT-8	Technical Area 55's Facilities Management Group
TA	technical area

ATTACHMENT B
INSPECTION PLAN

In accordance with the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.14(b)(5), and 20 NMAC 4.1, Subpart V, 264.15, "General Inspection Requirements," revised January 1, 1997 [1-1-97], inspection requirements for all hazardous and/or mixed waste management units at Los Alamos National Laboratory (LANL) are addressed in the "Inspection Plan" submitted to the New Mexico Environment Department as a permit modification request dated November 19, 1999 (LANL, 1999). This attachment presents additional inspection requirements specific to the proposed vitrification unit and vitrification unit slab tanks at Technical Area (TA) 55. Inspections will be conducted often enough to identify problems in time to correct them before they harm human health or the environment.

B.1 INSPECTION SCHEDULE AND REQUIREMENTS FOR THE VITRIFICATION UNIT [20 NMAC 4.1, Subpart V, 264.15(b) and 264.602]

The vitrification unit will be located at TA-55, Building 4, Room 434A and will be inspected according to the schedule provided below. The inspection frequency is based on the deterioration rate of equipment/systems and the probability of adverse impact to human health or the environment if failure of the equipment/systems or any operator error goes undetected between inspections.

B.1.1 Daily (During Operation)

The vitrification unit will be inspected each operating day (i.e., when waste is contained in the unit). For the daily inspection of the vitrification unit, the following items will be inspected, as appropriate, and recorded on the Inspection Record Form (IRF).

- Work surfaces/floors
- Secondary containment structure
- Labels
- Structural integrity of vitrification unit
- (Un)loading area.

B.1.2 Weekly

Weekly inspections of the vitrification unit will be conducted. For the weekly inspection of the vitrification unit, the following items will be inspected, as appropriate, and recorded on the IRF.

- Warning signs

- Work surfaces/floors
- Secondary containment structure
- Labels
- Structural integrity of vitrification unit
- (Un)loading area.

B.2 INSPECTION SCHEDULE AND REQUIREMENTS FOR THE VITRIFICATION UNIT SLAB TANKS [20 NMAC 4.1, Subpart V, 264.15(b), 264.193(i), and 264.195]

The vitrification unit slab tanks will be located at TA-55, Building 4, Room 434A and will be inspected according to the schedule provided below. The inspection frequency is based on the deterioration rate of equipment/systems and the probability of adverse impact to human health or the environment if failure of the equipment/systems or any operator error goes undetected between inspections.

B.2.1 Daily (During Operation)

The vitrification unit slab tanks (including ancillary equipment) will be inspected at least once each operating day. An operating day includes when mixed transuranic waste is added to or emptied from a tank. For daily inspections, the following items will be inspected, as appropriate, and recorded on the IRF:

- Work surface/floors
- Secondary containment structure
- Covers/lids of tanks
- Labels
- Structural integrity of tanks and ancillary equipment
- (Un)loading areas
- All portions of tank systems to detect corrosion or releases of waste and to detect any possible malfunctions to overfill/spill control equipment, tank monitoring and leak detection systems, and data from these systems
- Proper operating condition of tank.

B.2.2 Weekly

Weekly inspection of the vitrification unit slab tanks will be conducted and will include the following items, as appropriate:

- Warning signs
- Work surfaces/floors
- Secondary containment structures
- Covers/lids of tanks
- Labels
- Structural integrity of tanks and ancillary equipment
- (Un)loading areas

- All portions of tank systems to detect corrosion or releases of waste, overfill/spill control equipment, tank monitoring and leak detection systems, and data from these systems
- Proper operating condition of tank.

The inspection results will be recorded on the IRF.

B.2.3 Annually

An annual assessment is not necessary for the vitrification unit slab tanks and ancillary equipment, as required in 20 NMAC 4.1, Subpart V, 264.193(i) [1-1-97], because the vitrification unit slab tanks and the ancillary equipment will have secondary containment.

B.3 ADDITIONAL INSPECTION ITEMS

The items listed below are inspected monthly and documented by TA-55's Facilities Management Group (NMT-8):

- evacuation alarms
- ventilation alarms
- fire alarms
- fire pumps
- fire extinguishers
- communication equipment
- eyewashes/safety showers

These inspection items may be changed at the discretion of NMT-8 to ensure consistency with the inspection items and frequencies specified in the most current version of the "TA-55 Final Safety Analysis Report" (LANL, 1996) and the "TA-55 Technical Safety Requirements" (LANL, 2000).

Additionally, Protection Technology Los Alamos conducts daily security inspections of the fences and TA-55 access controls.

B.4 REFERENCES

LANL, 2000, "TA-55 Technical Safety Requirements," TA-55-PED-108-01.1, Los Alamos National Laboratory, Los Alamos, New Mexico.

LANL, 1999, "Los Alamos National Laboratory General Part B Plans Permit Modification Request," November 19, 1999, Los Alamos National Laboratory, Los Alamos, New Mexico.

LANL, 1996, "TA-55 Final Safety Analysis Report," LA-CP-95-169, Rev. 1., Los Alamos National Laboratory, Los Alamos, New Mexico.

PERSONNEL TRAINING

PERMIT ATTACHMENT C
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ATTACHMENT C
PERSONNEL TRAINING

In accordance with the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.14(b)(12), and 20 NMAC 4.1, Subpart V, 264.16, "Personnel Training," revised January 1, 1997, training requirements for treatment, storage, and disposal facility workers who will work with the vitrification unit and vitrification unit slab tanks at Technical Area 55 are provided in the "Personnel Training Plan" submitted to the New Mexico Environment Department as a permit modification request dated November 19, 1999 (Los Alamos National Laboratory [LANL], 1999).

C.1 REFERENCES

LANL, 1999, "Los Alamos National Laboratory General Part B Plans Permit Modification Request," November 19, 1999, Los Alamos National Laboratory, Los Alamos, New Mexico.

CONTINGENCY PLAN

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LIST OF ABBREVIATIONS/ACRONYMS

LANL	Los Alamos National Laboratory
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
TA	technical area

ATTACHMENT D
CONTINGENCY PLAN

In accordance with the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, Part 264, Subpart D, "Contingency Plan and Emergency Procedures," and 20 NMAC 4.1, Subpart IX, 270.14(b)(7), revised January 1, 1997, contingency measures applicable to the vitrification unit and the vitrification unit slab tanks at Technical Area (TA) 55 are provided in the "Contingency Plan" submitted to the New Mexico Environment Department as a permit modification request dated November 19, 1999 (Los Alamos National Laboratory [LANL], 1999).

Figure D-1 shows evacuation routes and muster areas that may be used at TA-55 in the event of an emergency. In addition, a list of emergency equipment that will be available for use near the vitrification unit and vitrification unit slab tanks at TA-55 is included as Table D-1. The vitrification unit and the vitrification unit slab tanks will be located at TA-55, Building 4, Room 434A. Room 434A is located within Room 401. Evacuation routes, muster area locations, and emergency equipment are subject to change.

D.1 REFERENCES

LANL, 1999, "Los Alamos National Laboratory General Part B Plans Permit Modification Request," November 19, 1999, Los Alamos National Laboratory, Los Alamos, New Mexico.

Table D-1[a]

Emergency Equipment

Technical Area (TA) 55

Emergency equipment at TA-55, Building 4 (TA-55-4), First Floor:

FIRE CONTROL EQUIPMENT:

Halon fire extinguishers are located in Rooms 401 and 434A.
Description of General Capabilities:
The fire extinguishers are portable, manually-operated units. They may be used by any employee in case of fire. The fire extinguishers in Room 434A are for use only in case of fire outside the glovebox.

Fire alarm pull boxes and push button stations are available in Room 401.
Description of General Capabilities:
Fire alarms may be activated by any employee in the event of fire to notify the Central Alarm System.

An automatic fire suppression sprinkler system is located in Rooms 401 and 434A.

Automatic thermal alarms are located in the glovebox in Room 434A.

Fire hydrants are located outdoors on the north, south, and west sides of TA-55-4.

SPILL CONTROL EQUIPMENT:

Room 434A will provide secondary containment for the vitrification unit and the vitrification unit slab tanks.

A mobile spill cart is located in the east-west corridor of TA-55-4 between Rooms 420 and 429. This spill cart may be transported to any spill location. The cart's contents include, but are not limited to, the following items: protective suits; polyethylene booties; latex, polyethylene, and neoprene gloves; chemical protective goggles; gas mask canisters; masking, vinyl, and caution tape (acid/caustic); spill pillows; neutral acid and neutral base with spray triggers; base neutralizer; tools; cheesecloth; and a vinyl bag.

Spill pillows may be used to construct simple berms.

Table D-1[a] (continued)

Emergency Equipment

Emergency equipment at TA-55-4, First Floor (continued):

COMMUNICATION EQUIPMENT:

Telephones are located in Room 401. The telephones are capable of handling incoming and outgoing calls and paging within the 400 area.

A telephone is located at each of the two west exit doors of TA-55-4.

Two-way radios are available, as needed, from the Nuclear Materials Technology Facilities Management Group (NMT-8) at the TA-55-3 Operations Center for personnel working in Rooms 401 and 434A.

Alarms at TA-55-4:
The fire alarm is a zone-wide whooping sound.
For the dropbox fire alarm, if a dropbox push button station is used, a zone-wide high-pitched constant tone will also be activated.
The evacuation alarm is a facilitywide mid-range pulsating tone.
The continuous air monitor alarm is a local high-pitched pulsating tone.
The ventilation alarm is a local slow, repeating chime tone.

The public address system may also be used to announce an evacuation.

DECONTAMINATION EQUIPMENT:

Safety showers are located in Room 401.
Eyewashes are located in Room 401.

Material Safety Data Sheets (MSDS) for each chemical handled are available in Room 401.
Description of General Capabilities:
Safety showers and eyewashes are used by personnel who receive a chemical splash to the skin or eyes. Specific MSDSs should be obtained prior to working with mixed waste to determine if the application of water is indicated for decontamination.

Table D-1[a] (continued)

Emergency Equipment

Emergency equipment at TA-55-4, First Floor (continued):

PERSONAL PROTECTIVE EQUIPMENT:

Self-contained breathing apparatus (SCBA) are located in the hallway outside of Room 401. Additional SCBAs are located in the northside hallway in TA-55-4. They are available for personnel working in or near Rooms 401 and 434A.

Additional SCBA are available in TA-55-1.

Change/decontamination rooms with protective clothing available are located on the first floor of TA-55-4 and in TA-55-3. Protective clothing is also available in the Health Physics Operations Group (ESH-1) locker located in the hallway near Room 401 for use by personnel working in or near Rooms 401 and 434A.

Respirators located in TA-55-3 (Room 107) and in TA-55-4 (Room 515) are available for all personnel working in or near TA-55-4. Particulate and toxic gas canisters are available in TA-55-4 (Room 515).

OTHER:

The ESH-1 locker located in the hallway near Room 401 may contain, but is not limited to, the following items: hoods, sleeves, paper coveralls, probes, Nu-con smears, Nu-con smear holders, radiation tags, labels, radioactive contamination tape, shurtape (silver), earphones, fixed head filters (holders), and chemical spill pillows. These items are available for personnel working in or near Rooms 401 and 434A.

Vehicles for evacuation of personnel are available through the Emergency Management and Response Office at TA-59-1.

Portable emergency generators (110 volts) are available from the NMT-8 Support Office at TA-55-3.

One emergency cabinet with fire and rescue equipment located in the hallway near Room 401 contains, but is not limited to, the following items: rescue rope, masking tape, surgeon gloves, high tension gloves, lantern and batteries, blanket, hard hat, Kwik heat pad, first aid kits, extra oxygen bottles, bolt cutters, pik-headed axe, collapsible stretcher, and extendable Tel-o-Pole.

One Emergency Response Team supply cart is located in the hallway between Rooms 420 and 429.

[a]Equipment types and locations are subject to change.

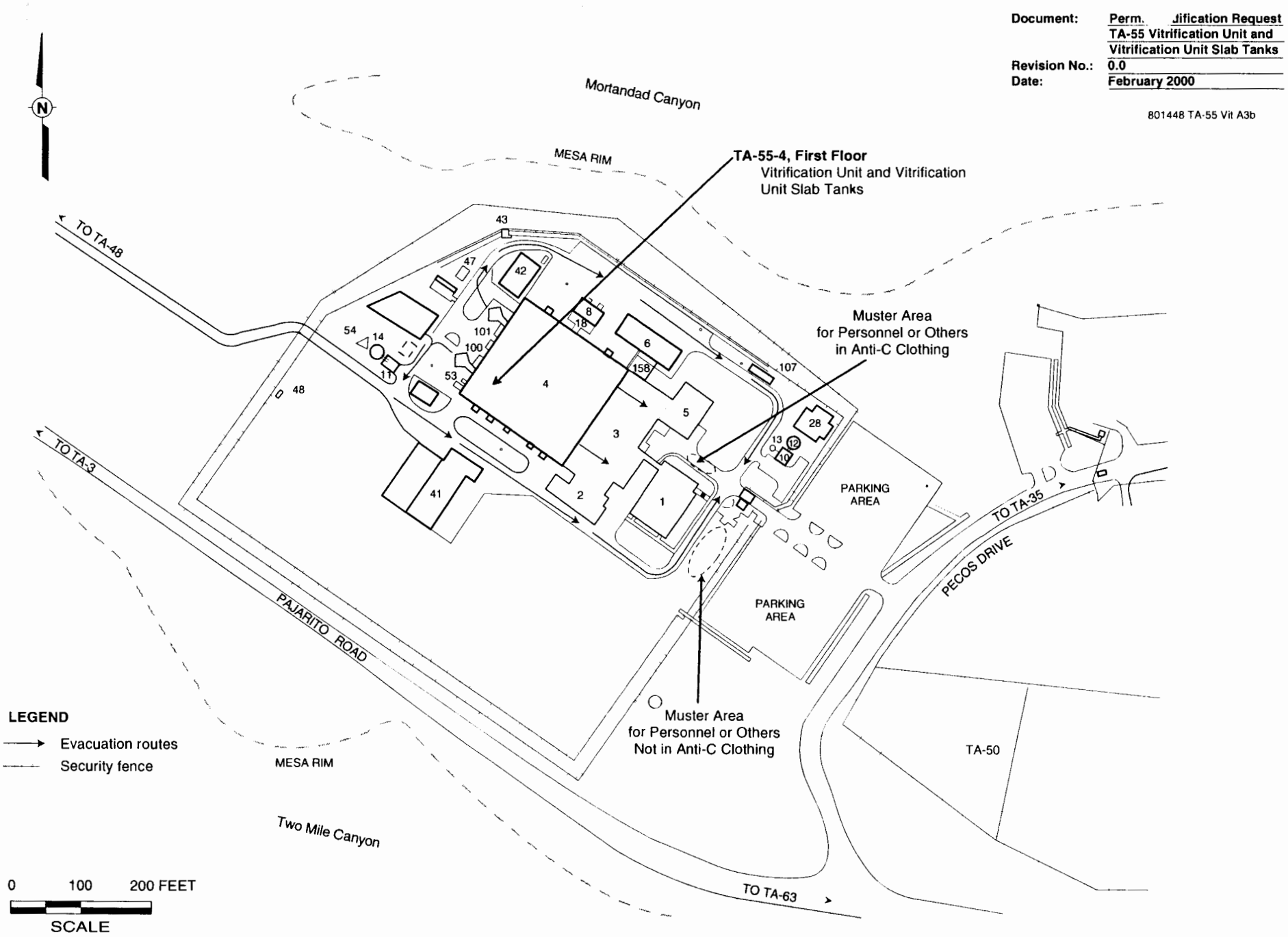

Figure D-1
Evacuation Routes and Muster Areas at Technical Area (TA) 55

CLOSURE PLAN
FOR THE
TECHNICAL AREA 55 VITRIFICATION UNIT

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LIST OF ABBREVIATIONS/ACRONYMS

COLIWASA	composite liquid waste sampler
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LANL	Los Alamos National Laboratory
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
NMED	New Mexico Environment Department
NMT	Nuclear Materials Technology
PPE	personal protective equipment
QA/QC	quality assurance/quality control
RCRA	Resource Conservation Recovery Act
SW-846	EPA's "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods"
TA	technical area
TRU	transuranic waste

ATTACHMENT E.1

CLOSURE PLAN FOR THE TECHNICAL AREA 55 VITRIFICATION UNIT

E.1.1 INTRODUCTION

The information provided in this closure plan is submitted to address the applicable closure requirements specified in the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.14(b)(13) and 20 NMAC 4.1, Subpart V, Part 264, Subparts G and X, revised January 1, 1997 [1-1-97]. This closure plan describes the activities necessary to close the vitrification unit to be located at Los Alamos National Laboratory (LANL) Technical Area (TA) 55. Closure activities will minimize the need for further maintenance, preclude the release of hazardous constituents to environmental media, and be protective of human health, in accordance with the closure performance standards specified in 20 NMAC 4.1, Subpart V, 264.111 [1-1-97].

The vitrification unit will be located at TA-55, Building 4, Room 434A, inside Room 401. The vitrification unit will be used to stabilize evaporator bottoms solutions, a mixed transuranic (TRU) waste, into a glass matrix. The vitrification unit will consist of a single batch in-can melter, glass frit feed system, glass/waste handling system, off-gas system, associated structures, glovebox, and piping. The proposed location of the vitrification unit is shown in Figure E.1-1.

E.1.2 ESTIMATE OF MAXIMUM INVENTORY OF WASTE [20 NMAC 4.1, Subpart V, 264.112(b)(3)]

The maximum volume of mixed TRU waste that may be inventoried in the vitrification unit at any time is estimated at 27 gallons.

E.1.3 DESCRIPTION OF WASTE

The vitrification unit will be used to treat evaporator bottoms solutions, a mixed TRU waste, generated primarily from research and development activities and processing and recovery operations. These waste solutions are generated as evaporator bottoms and generally consist of concentrated nitric acid saturated with salts and metals. The evaporator bottoms solutions waste is classified as mixed TRU waste because Resource Conservation and Recovery Act (RCRA)-characteristic wastes are or may be present, along with radioactive components. The evaporator

bottoms solutions waste typically exhibits the hazardous characteristics of toxicity (for metals) and corrosivity.

E.1.4 REMOVAL OF WASTE

Prior to the initiation of closure activities, evaporator bottoms solutions waste remaining in the vitrification unit will be removed or treated according to current waste-specific standard operating procedures. Once the evaporator bottoms solutions waste has been removed or treated, the melter can(s) of treated vitrified waste will be removed and transported to an approved on-site facility or a permitted off-site treatment, storage, and disposal facility.

E.1.5 PARTIAL AND FINAL CLOSURE ACTIVITIES [20 NMAC 4.1, Subpart V, 264.112(b)(2) and 264.112(d)]

This closure plan has been written for partial closure rather than final closure of the entire LANL facility. Partial closure will consist of closing the vitrification unit, vitrification unit ancillary equipment (e.g., glass frit feed system, off-gas system, associated structures, piping), and/or glovebox at TA-55, while leaving the other hazardous and mixed waste management units at LANL in service. Partial closure (hereinafter referred to as closure) will be deemed complete when decontamination, decommissioning, or dismantling has been verified; the vitrification unit (or portion thereof) and related equipment and surfaces have been decontaminated, decommissioned, or dismantled, if necessary; the closure certification has been submitted to the New Mexico Environment Department (NMED); and the NMED has approved the closure. Final closure will occur when LANL's remaining RCRA-regulated hazardous and mixed waste management units are closed either by waste removal and decontamination or by disposal of contaminated structures and equipment.

E.1.6 CLOSURE PROCEDURES [20 NMAC 4.1, Subpart V, 264.112(b)(4) and (5), and 264.114]

All contaminated surfaces and equipment associated with the vitrification unit will be decontaminated, decommissioned, or dismantled, depending on the extent of contamination and anticipated disposition or use after closure. Monitoring for contamination will occur throughout closure activities, as appropriate.

Personnel involved in closure activities will wear appropriate personal protective equipment (PPE), specified by LANL's Health Physics Operations Group and Industrial Hygiene and Safety Group, and will follow good hygiene practices to protect themselves from exposure to contamination. The level of PPE that will be required will depend upon the levels of contamination that are detected, if any.

Minimum PPE requirements will consist of coveralls, steel-toed shoes, and safety glasses or face shields. If an overhead danger is present, a hard hat will also be worn. All workers involved in closure activities will be required to have appropriate training and medical monitoring. Contaminated PPE will be decontaminated or managed in compliance with appropriate regulations.

The following sections provide closure procedures specific to the vitrification unit equipment and glovebox, ancillary equipment, and areas adjacent to the vitrification unit.

E.1.6.1 Vitrification Unit Equipment and Glovebox

The vitrification unit equipment (e.g., melter, cooling jackets, glass/waste handling system) and glovebox will either be decontaminated, decommissioned, or dismantled, depending on the extent of contamination and anticipated disposition or use after closure. If any of the vitrification unit equipment and/or glovebox is to be decommissioned or dismantled, the resulting components will be containerized and managed in compliance with appropriate regulations. If any of the vitrification unit equipment and/or glovebox is to be decontaminated, Nuclear Materials Technology (NMT) personnel will use the following procedures.

Prior to decontamination of any of the vitrification unit equipment, any visible material (e.g., glass frit, scraps) located inside the glovebox will be removed to the extent possible and managed in compliance with appropriate regulations. The vitrification unit equipment located inside the glovebox will be rinsed or flushed with wash water or wiped down with sponges, as appropriate, to minimize the amount of liquid waste generated. The wash water will be collected (squeezed from sponges, if necessary), transferred to containers, sampled, and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. The used wash water will be managed appropriately in accordance with LANL policy. The wash cycles will continue until the equipment to be decontaminated has been cleaned to established levels or the decision is made to manage it as contaminated waste. Equipment to be managed as contaminated waste will be containerized and managed in compliance with appropriate regulations.

The interior surfaces of the vitrification unit glovebox will be wiped down with sponges to minimize the amount of liquid waste generated as a result of decontamination activities. The used wash water will be squeezed from the sponges, collected, transferred to containers, sampled, and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. The used wash water will be managed appropriately in accordance with LANL policy. Wash cycles will

continue until the inside of the vitrification unit glovebox has been cleaned to established levels or the decision is made to manage it as contaminated waste. Equipment to be managed as contaminated waste will be containerized and managed in compliance with appropriate regulations.

E.1.6.2 Vitrification Unit Ancillary Equipment

The vitrification unit ancillary equipment (e.g., glass frit feed system, off-gas system, associated structures, piping, drum-handling equipment) located inside Room 434A (outside the glovebox) will either be decontaminated, decommissioned, or dismantled, depending on the extent of contamination and anticipated disposition or use after closure. If any of the vitrification unit ancillary equipment is to be decommissioned or dismantled, the resulting components will be containerized and managed in compliance with appropriate regulations. If decontamination measures are deemed appropriate, NMT personnel will use the following procedures for surface decontamination of the vitrification unit ancillary equipment.

Random swipe samples from vitrification unit ancillary equipment located adjacent to the vitrification unit glovebox will be collected initially and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. Based upon the analytical results, the vitrification unit ancillary equipment to be decontaminated will be rinsed or flushed with wash water or wiped down with sponges, as appropriate, to minimize the amount of liquid waste generated. The wash water will be collected (squeezed from sponges, if necessary), transferred to containers, sampled, and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. Wash cycles will continue until the equipment has been cleaned to established levels or the decision is made to manage it as contaminated waste. One additional sample of clean wash water solution squeezed from the mops and/or sponges prior to use will be collected for each additional wash cycle. Used wash water will be managed appropriately in accordance with LANL policy. Equipment to be managed as contaminated waste will be containerized and managed in compliance with appropriate regulations.

E.1.6.3 Areas Adjacent to the Vitrification Unit Glovebox

Random swipe samples from the areas adjacent to the vitrification unit glovebox (e.g., walls, floors) will be collected and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. If decontamination measures are deemed necessary based on the analytical results, NMT personnel will use the following procedures to accomplish surface decontamination of the walls and floors, as appropriate.

The floor area and wall(s) adjacent to the vitrification unit glovebox will be washed down using mops and sponges to minimize the amount of liquid waste generated as a result of decontamination activities. The used wash water will be squeezed from the mops and sponges, collected, transferred to appropriate containers, sampled, and analyzed for the parameters listed in Table E.1-1 and expected to be present based on the operating record. Wash cycles will continue until the floor area and walls adjacent to the vitrification unit glovebox have been cleaned to established levels. One additional sample of clean wash water solution squeezed from mops and/or sponges prior to use will be collected for each additional wash cycle. Used wash water will be managed appropriately in accordance with LANL policy.

E.1.6.4 Decontamination Equipment

Prior to use, all reusable decontamination equipment will be rinsed with distilled water. Decontamination equipment rinsate blanks will be collected and analyzed in accordance with a written quality assurance/quality control (QA/QC) plan. Following decontamination activities, reusable protective clothing, tools, and equipment used during closure activities will be cleaned with a wash water solution. Disposable or reusable equipment that cannot be decontaminated will be containerized and managed in compliance with appropriate regulations.

E.1.6.5 Verification of Decontaminated Items

Sufficient sampling and analysis will be required to demonstrate that, after decontamination, hazardous constituents are not present above regulatory levels. Two samples of clean wash-water solution squeezed from mops and sponges, prior to use, will be collected before initial washdown of items to be decontaminated. The samples will be analyzed for the parameters listed in Table E.1-1 expected to be present in the used wash water based on the operating record. The analytical results from these samples will be used to provide baseline data for decontamination verification. Analytical procedures will conform to methods found in the most current version of "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (*SW-846*) (U.S. Environmental Protection Agency [EPA], 1986). Used wash water will be analyzed for the same parameters. Used washwater will be considered contaminated if it shows a significant increase (i.e., determined using statistical methods defined in *SW-846)* in the analytical parameters over the clean wash water. If subsequent washdowns are deemed necessary, an additional sample of clean wash water squeezed from sponges prior to use will be taken for each additional washdown event.

Successful decontamination meets one of the following criteria:

- No detectable RCRA-regulated constituent residues from the management of authorized RCRA-regulated wastes are identified in samples collected during closure activities.
- Analytical results of samples collected during closure activities identify no statistically significant concentrations of RCRA-regulated constituents above baseline data.
- Detectable concentrations of RCRA-regulated constituents in samples collected during closure activities are at or below levels agreed upon with the NMED to be protective of human health and the environment based on the results of risk assessment methods.
- Detectable concentrations of RCRA-regulated constituents that cannot be removed or decontaminated to acceptable levels as described above will be allowed to remain provided that these RCRA-regulated constituents do not pose an unacceptable risk when combined with technical or administrative control measures agreed upon with the NMED.

An alternative demonstration of decontamination may be proposed and justified at the time of unit closure as circumstances indicate. The NMED will evaluate the proposed alternative in accordance with the standards and guidance then in effect and, if approved, incorporate the alternative into this closure plan.

E.1.7 CLOSURE SCHEDULE [20 NMAC 4.1, Subpart V, 264.112(b)(6) and 264.113]

Closure activities will begin in accordance with the approved closure plan, as required by 20 NMAC 4.1, Subpart V, 264.113(a) [1-1-97], within 90 days after final receipt of evaporator bottoms solutions waste at the vitrification unit. This timeframe will be met as long as facilities are available for disposal of the treated vitrified waste form. In the event that closure activities cannot be completed at the vitrification unit within 90 days, LANL will notify the Secretary of the NMED in accordance with the extension requirements cited in 20 NMAC 4.1, Subpart V, 264.113(a) [1-1-97]. Closure activities and reporting requirements will be completed within 180 days of the receipt of the final volume of evaporator bottoms solutions waste at the vitrification unit. Closure will be conducted in accordance with the schedule presented in Table E.1-2 of this closure plan. In the event that closure of the vitrification unit is prevented from proceeding according to schedule, LANL will notify the Secretary of the NMED in accordance with extension request requirements in 20 NMAC 4.1, Subpart V, 264.113(b) [1-1-97]. In addition, the demonstrations in 20 NMAC 4.1, Subpart V, 264.113(a)(1) and (b)(1) [1-1-97], will be made in accordance with 20 NMAC 4.1, Subpart V, 264.113(c) [1-1-97].

E.1.8 CLOSURE CERTIFICATION [20 NMAC 4.1, Subpart V, 264.115]

Within 60 days after completion of closure activities for the vitrification unit, the U.S. Department of Energy (DOE) will submit to the Secretary of the NMED, via certified mail, a certification that the vitrification unit has been closed in accordance with the specifications of the closure plan. The certification will be attested to by an independent, registered professional engineer and will be signed by the appropriate DOE and LANL officials, in accordance with 20 NMAC 4.1, Subpart V, 264.115 [1-1-97]. Documentation supporting the independent registered engineer's certification will be furnished to the Secretary of the NMED with the original certification. Both the DOE/Los Alamos Area Office and LANL's Hazardous and Solid Waste Group shall maintain a copy of the certification and supporting documentation.

E.1.9 SAMPLING AND ANALYTICAL PROCEDURES [20 NMAC 4.1, Subpart V, 264.112(b)(4)]

The following sections describe procedures and methods for sampling, analysis, and documentation applicable to decontamination activities. While the procedures and methods are specific, other applicable procedures or methods given in *SW-846* (EPA, 1986) may be used if conditions or experience show the alternate method to be more appropriate. All sampling and analytical procedures actually used will be annotated in the final closure report. Sampling will be conducted in accordance with procedures given in *SW-846* for hazardous components. All sampling conducted during closure will be done in accordance with a written QA/QC plan.

E.1.9.1 Liquid Sampling

A composite liquid waste sampler (COLIWASA) or similar device will be used to sample unused wash water solutions before decontamination begins in order to determine baseline parameters. It will also be used to sample the wash water used in decontaminating the vitrification unit. As an alternative to the COLIWASA, glass tubes may be used to sample liquids.

E.1.9.1.1 Cleaning of Samplers

The sampler must be clean before use. An unused, disposable sampler will be presumed clean if still in a factory-sealed wrapper. Unsealed samplers will be cleaned prior to use. Samplers will be washed with a detergent and water solution, rinsed several times with tap water, rinsed with distilled water, drained of excess water, and air-dried or wiped dry. Clean samplers should be stored in clean polyethylene plastic tubes or bags in a clean and protected area.

E.1.9.1.2 Sampling Procedure

Liquid sampling with a COLIWASA will be performed as follows:

- Ensure that the COLIWASA is clean.
- Assemble the COLIWASA.
- Check that the sampler is functioning properly. Adjust the locking mechanism, if necessary, to make sure the neoprene rubber stopper provides a tight closure.
- Wear necessary protective clothing and gear, and observe required sampling precautions.
- Put the sampler in the open position by placing the stopper-rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
- Slowly lower the COLIWASA into the liquid at a rate that permits the level of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and will result in a nonrepresentative sample.
- When the sampler stopper hits the bottom of the liquid container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
- Slowly withdraw the sampler from the container with one hand, while wiping the sampler tube with a disposable cloth with the other hand.
- Carefully discharge the sample into a sample container by slowly opening the sampler. This is done by slowly pulling the lower end of the T-handle away from the locking block, while the lower end of the sampler is positioned in the sample container.
- Preserve as required (see Table E.1-3), cap the container, attach a label and seal, place immediately in an insulated container with ice (if required), record in the field logbook, and complete the sample analysis request sheet and chain-of-custody form.
- Unscrew the T-handle of the sampler and disengage the locking block. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube or bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

E.1.9.2 Sample Handling and Documentation

Samples will be analyzed either at LANL or at a commercial laboratory. Each sample will be labeled, sealed, and accompanied by a chain-of-custody and sample analysis request form. The chain-of-custody form is necessary to trace sample possession from the time of collection to the time of analysis and must accompany every sample. The original record will accompany shipment. The copy is retained by LANL. If samples are analyzed at LANL, the original will be maintained by LANL.

The request for analysis form has two parts: field and laboratory. The field portion of this form will be completed by the person collecting the sample and include most of the pertinent information noted in the logbook. The analytical laboratory personnel will complete the laboratory portion when the sample is received. The analytical laboratory retains the original record and sends a copy to LANL.

Sample containers appropriate for the requested analyses will be used for all samples. Sample containers, preservation, and holding times will conform to those specified in *SW-846* (EPA, 1986) for the corresponding analyses. Samples will be collected, placed in bottles, sealed, and tagged. Sample container surfaces will be screened for radiological contamination and decontaminated, if necessary. Sample containers will then be immediately packed in vermiculite, sawdust, or if refrigeration is required, an insulated container with ice. Recommended sample containers, preservation, and holding times are presented in Table E.1-3.

The sample container will be sealed in such a way that the seal must be broken in order to open the container. The seal and sample tag will be completed with a waterproof pen. The sample label will be completed to include the project name, sample number, collection date/time, collector's name, sample location, sample media description, preservative, and analysis requested.

A field logbook will be kept and will contain all information pertinent to field surveys and sampling. Examples of entries include:

- Purpose of sample (routine sampling, special sampling)
- Location of sampling
- Name and business address of person making log entry
- Type of process producing waste
- Number and volume of sample
- Description of each sampling location, sampling methodology, equipment used, etc.
- Date and time of sample collection
- Sample destination and transporter's name (e.g., name of laboratory, United Parcel Service)

- Map or photograph of the sampling site, if any
- Field observations, if applicable
- Field measurements, if applicable (e.g., pH, conductivity)
- Collector's sample identification number(s)
- Signature of person responsible for the log entry.

Because sampling situations vary widely, no specific rule can be given as to the extent of information that must be entered in the logbook. However, sufficient information will be recorded so that someone can reconstruct the sampling situation without relying on the collector's memory.

E.1.10 QUALITY ASSURANCE/QUALITY CONTROL

A qualified individual or individuals will be designated to independently oversee the closure activities and to report directly to senior management on the quality of the closure performance. This individual will personally observe a portion of the key activities, assure that sample blanks are used and analyzed, and review the analysis reports for accuracy and adequacy. A written QA/QC plan prepared in accordance with *SW-846* (EPA, 1986) guidance will be prepared and followed, with variations from the plan documented and explained. The designated individual will prepare a written statement for the final report commenting on the level of decontamination verification achieved.

E.1.11 CLOSURE REPORT

Upon completion of the closure activities for the vitrification unit, a closure report will be submitted to the Secretary of the NMED. The report will document the closure and contain a closure certification (see E.1.7), a description of any variances from approved procedures, a summary of the sampling results, a QA/QC statement, the location of the file of supporting documentation, disposition location of RCRA-regulated closure materials, and a certification of accuracy of the report.

E.1.12 CLOSURE COST ESTIMATE, FINANCIAL ASSURANCE, AND LIABILITY REQUIREMENTS [20 NMAC 4.1, Subpart V, 264.140(c)]

In accordance with 20 NMAC 4.1, Subpart V, 264.140(c) [1-1-97], LANL, as a federal facility, is exempt from the requirements of 20 NMAC 4.1, Subpart V, Part 264, Subpart H [1-1-97] to provide a cost estimate, financial assurance mechanisms, and liability insurance for closure actions.

E.1.13 SURVEY PLAT AND POST-CLOSURE REQUIREMENTS [20 NMAC 4.1, Subpart V, 264.116 and 264.117 through 264.120]

It is the intent of LANL to either remove hazardous and mixed waste constituents from the vitrification unit through decontamination of surfaces and equipment to established cleanup levels or to decommission or dismantle, and dispose of the contaminated surfaces and equipment. LANL will amend this closure plan, as necessary, to address changes to closure procedures or post-closure care pursuant to 20 NMAC 4.1, Subpart V, 264.117 through 264.120 [1-1-97]. A survey plat, post-closure certification, and post-closure notices will not be required because, subject to this closure plan, unless amended, all waste will be removed and the vitrification unit will be decontaminated or disposed of at closure. Therefore, these requirements are not applicable.

E.1.14 AMENDMENT OF PLAN [20 NMAC 4.1, Subpart V, 264.112(c)]

In accordance with 20 NMAC 4.1, Subpart IX, 264.112(c), LANL will submit a written notification of or request for a permit modification to authorize a change in the approved closure plan whenever:

- There are changes in operating plans or facility design that affect the closure plan
- There is a change in the expected year of closure
- Unexpected events occur during closure that require modification of the approved closure plan.

The written notification or request will include a copy of the amended closure plan for approval by the NMED.

LANL will submit a written request for a permit modification with a copy of the amended closure plan at least 60 days prior to the proposed change in unit design or operation or no later than 60 days after an occurrence of an unexpected event that affects the closure plan. If the unexpected event occurs during closure, the permit modification will be requested within 30 days of the occurrence. If the Secretary of the NMED requests a modification of the closure plan, a plan modified in accordance with the request will be submitted within 60 days of notification or within 30 days of notification if a change in facility condition occurs during the closure process.

E.1.15 REFERENCES

EPA, 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.

Table E.1-1

Analytical Parameters and Test Methods[a]

Parameter	Test Method	Reference
Corrosivity	Electrometric (pH of aqueous solution)	SW-846 (9040B)[b] or equivalent methods
TC Metals:	Atomic absorption,	SW-846
Arsenic	Furnace technique,	(3010A, 6010B, 7060A[c], 7061A)[b]
Barium	Gaseous hydride,	(3010A, 6010B, 7080A[d], 7081[c])[b]
Cadmium	Direct aspiration, and	(3010A, 6010B, 7130[d], 7131A[c])[b]
Chromium	Borohydride reduction	(3010A, 6010B, 7190[d], 7191[c])[b]
Lead	Acid Digestion	(3010A, 6010B, 7420[d], 7421[c])[b]
Silver	Inductively coupled plasma atomic emission spectroscopy	(3010A, 6010B, 7760A[d], 7761[c])[b]
TC Mercury	Manual cold-vapor technique	(3010A, 6010B, 7470A) or equivalent methods

[a] At Los Alamos National Laboratory, current analytical capabilities include limited analyses of mixed transuranic waste samples. These analyses include, but are not limited to, gross alpha, beta, and gamma screening.
[b] U.S. Environmental Protection Agency, 1986 and all approved updates "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.
[c] Method being integrated into Method 7000B, per the January 1998 SW-846 Draft Update IV A.
[d] Method being integrated into Method 7010, per the January 1998 SW-846 Draft Update IV A.

TC = toxicity characteristic

Table E.1-2

Closure Schedule for the Technical Area 55 Vitrification Unit

Activity	Maximum Time Required[a]
Let contract request for proposals	-90 Days
Notify the New Mexico Environment Department (NMED)	-45 Days
Receive proposals	-30 Days
Select contractor and award contract	-10 Days
Treatment and removal of final waste volume	Day 5
Perform washdown of vitrification unit, collect samples from wash water, submit samples for analyses	Day 15
Receive analyses on samples from the vitrification unit	Day 45
Perform additional washdown (if necessary)	Day 50
Perform additional sampling and submit for analyses (if necessary)	Day 50
Receive analyses on samples from additional sampling	Day 80
Equipment disassembly	Day 100
Perform final cleanup (e.g., removal of decontaminated equipment and decontamination wastes)	Day 110
Verify decontamination	Day 125
Submit final report to the NMED	Day 180

[a] The schedule above indicates calendar days from the beginning by which activities will be completed. Some activities may be conducted simultaneously.

Table E.1-3

Sample Containers, Preservation, and Holding Times[a]

Analyte Group	Container[b]	Preservative	Holding Time[c]
TC Metals Arsenic Barium Cadmium Chromium Lead Silver	600 ml P or G	HNO_3 to pH <2	180 days
TC Mercury	400 ml P or G	HNO_3 to pH <2; cool to 4°C	28 days

[a] Holding time information was taken from U.S. Environmental Protection Agency (EPA), 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846,* Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.

[b] Smaller sample containers may be required due to health and safety concerns associated with potential radiation exposure, transportation requirements, and waste management considerations.

[c] Holding time from when the sample is taken.

°C = degrees Celsius
G = Glass
HNO_3 = Nitric acid
ml = milliliters
P = Polyethylene
TC = Toxicity characteristic

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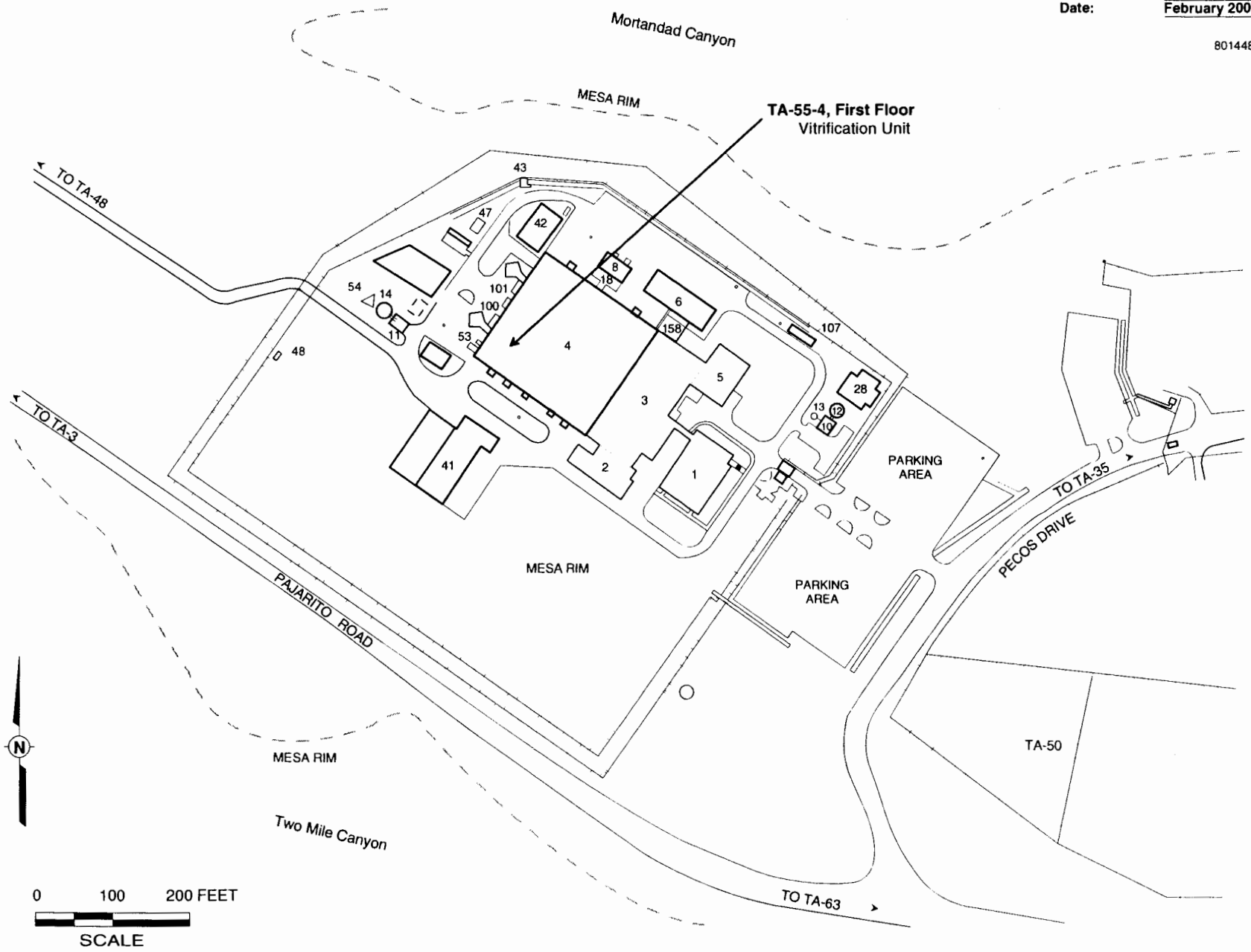

Figure E.1-1
Technical Area (TA) 55 Vitrification Unit

CLOSURE PLAN FOR THE TECHNICAL AREA 55 VITRIFICATION UNIT SLAB TANKS

PERMIT ATTACHMENT E.2
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LIST OF ABBREVIATIONS/ACRONYMS

COLIWASA	composite liquid waste samples
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LANL	Los Alamos National Laboratory
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
NMED	New Mexico Environment Department
PPE	personal protective equipment
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
SW-846	EPA's "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods"
TA	technical area
TRU	transuranic

ATTACHMENT E.2

CLOSURE PLAN FOR THE TECHNICAL AREA 55 VITRIFICATION UNIT SLAB TANKS

E.2.1 INTRODUCTION

The information provided in this closure plan is submitted to address the applicable closure requirements specified in the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.14(b)(13) and 20 NMAC 4.1, Subpart V, Part 264, Subparts G and J, revised January 1, 1997 [1-1-97]. This closure plan describes the activities necessary to close the vitrification unit slab tanks to be located at Los Alamos National Laboratory (LANL) Technical Area (TA) 55. Closure activities will minimize the need for further maintenance, preclude the release of hazardous constituents to environmental media, and be protective of human health, in accordance with the closure performance standards specified in 20 NMAC 4.1, Subpart V, 264.111 [1-1-97].

The vitrification unit slab tanks will be located at TA-55, Building 4, Room 434A. The vitrification unit slab tanks will be used to store evaporator bottoms solutions, a mixed transuranic (TRU) waste, prior to treatment in the vitrification unit. The proposed location of the vitrification unit slab tanks is shown on Figure E.2-1.

E.2.2 ESTIMATE OF MAXIMUM INVENTORY OF WASTE [20 NMAC 4.1, Subpart V, 264.112(b)(3)]

The maximum inventory of mixed TRU waste that may be stored in the vitrification unit slab tanks at any time is 250 liters (66 gallons).

E.2.3 DESCRIPTION OF WASTE

The vitrification unit slab tanks will be used to store evaporator bottoms solutions, a mixed TRU waste, generated from research and development activities and processing and recovery operations. This waste is generated as evaporator bottoms and generally consists of concentrated nitric acid saturated with salts and metals. The evaporator bottoms solutions waste is classified as mixed TRU waste because Resource Conservation and Recovery Act (RCRA)-characteristic wastes are or may be present, along with radioactive components. The evaporator bottoms solutions waste typically exhibits the hazardous characteristics of toxicity (for metals) and corrosivity.

E.2.4 REMOVAL OF WASTE

Prior to the initiation of closure activities, any evaporator bottoms solutions waste remaining in the vitrification unit slab tanks will be removed or discharged into the vitrification unit and treated according to current waste-specific standard operating procedures.

E.2.5 PARTIAL AND FINAL CLOSURE ACTIVITIES [20 NMAC 4.1, Subpart V, 264.112(b)(2) and 264.112(d)]

This closure plan has been written for partial closure rather than final closure of the entire LANL facility. Partial closure will consist of closing the vitrification unit slab tanks and/or ancillary equipment at TA-55, while leaving the other hazardous and mixed waste management units at LANL in service. Partial closure (hereinafter referred to as closure) will be deemed complete when decontamination, decommissioning, or dismantling has been verified; the vitrification unit slab tanks (or portion thereof) and related equipment and surfaces have been decontaminated, decommissioned, or dismantled, if necessary; the closure certification has been submitted to the New Mexico Environment Department (NMED); and the NMED has approved the closure. Final closure will occur when LANL's remaining RCRA-regulated hazardous and mixed waste management units are closed either by waste removal and decontamination or by disposal of contaminated structures and equipment.

E.2.6 CLOSURE PROCEDURES [20 NMAC 4.1, Subpart V, 264.112(b)(4) and (5), and 264.114]

All contaminated surfaces and equipment associated with the vitrification unit slab tanks will either be decontaminated, decommissioned, or dismantled, depending on the extent of contamination and anticipated disposition or use after closure. Monitoring for contamination will occur throughout closure activities, as appropriate.

Personnel involved in closure activities will wear appropriate personal protective equipment (PPE), specified by LANL's Health Physics Operations Group and Industrial Hygiene and Safety Group, and will follow good hygiene practices to protect themselves from exposure to contamination. The level of PPE that will be required will depend upon the levels of contamination that are detected, if any. Minimum PPE requirements will consist of coveralls, steel-toed shoes, and safety glasses or face shields. If an overhead danger is present, a hard hat will be worn. All workers involved in closure activities will be required to have appropriate training and medical monitoring. Contaminated PPE will either be decontaminated or managed in compliance with appropriate regulations.

The following sections provide closure procedures specific to the vitrification unit slab tanks, ancillary equipment, and areas adjacent to the vitrification unit slab tanks.

E.2.6.1 Vitrification Unit Slab Tanks

The vitrification unit slab tanks will be decommissioned at closure. Due to the design of the vitrification unit slab tanks, decontamination is not possible. The decommissioned vitrification unit slab tanks will be containerized and managed in compliance with appropriate regulations.

E.2.6.2 Vitrification Unit Slab Tanks Ancillary Equipment

The vitrification unit slab tanks ancillary equipment (e.g., piping, pumps) will either be decontaminated, decommissioned, or dismantled, depending on the extent of contamination and anticipated disposition or use after closure. If any of the vitrification unit slab tanks ancillary equipment is to be decommissioned or dismantled, the resulting components will be containerized and managed in compliance with appropriate regulations. If the vitrification unit slab tanks ancillary equipment is to be decontaminated, the following procedures will be used.

The interior surfaces of the vitrification unit slab tanks ancillary equipment will be flushed with wash water. Following the washdown, the wash water will be collected and analyzed for the parameters listed in Table E.2-1 and expected to be present based on the operating record. The exterior surfaces will be wiped down with a wash water solution using sponges to minimize the amount of liquid waste generated as a result of decontamination activities. The used wash water will be squeezed from the sponges and collected and analyzed for the parameters listed in Table E.2-1 and expected to be present based on the operating record. Used wash waster will be managed in accordance with LANL policy. The wash cycles will continue until the equipment has been cleaned to established levels or the decision is made to manage it as contaminated waste. Equipment to be managed as contaminated waste will be containerized and managed in compliance with appropriate regulations.

E.2.6.3 Areas Adjacent to the Vitrification Unit Slab Tanks

Random swipe samples from the areas adjacent to the vitrification unit slab tanks (e.g., walls, floors, sumps, and drains) will be collected and analyzed for the parameters listed in Table E.2-1 and expected to be present based on the operating record. If decontamination measures are deemed necessary based on the analytical results, the following procedures will be used.

The floor area, wall(s), and any recessed areas present (e.g., sumps and drains) adjacent to the vitrification unit slab tanks will be washed down using mops and sponges to minimize the amount of liquid waste generated as a result of decontamination activities. The used wash water will be squeezed from the mops and sponges and collected and analyzed for the parameters listed in Table E.2-1 and expected to be present based on the operating record. Wash cycles will continue until the floor area, walls, and recessed areas adjacent to the vitrification unit slab tanks have been cleaned to established levels. One additional sample of clean wash water solution squeezed from mops and/or sponges prior to use will be collected for each additional washdown event. Used wash water will be managed appropriately in accordance with LANL policy.

E.2.6.4 Decontamination Equipment

Prior to use, all reusable decontamination equipment will be rinsed with distilled water. Decontamination equipment rinsate blanks will be collected and analyzed in accordance with a written quality assurance/quality control (QA/QC) plan. Following decontamination activities, reusable protective clothing, tools, and equipment used during closure activities will be cleaned with a wash water solution. Disposable or reusable equipment that cannot be decontaminated will be containerized and managed in compliance with appropriate regulations.

E.2.6.5 Verification of Decontaminated Items

Sufficient sampling and analysis will be required to demonstrate that, after decontamination, hazardous constituents are not present above regulatory limits. Two samples of clean wash water solution squeezed from mops and/or sponges prior to use will be collected before initial washdowns of the items to be decontaminated. The samples will be analyzed for the parameters listed in Table E.2-1 and expected to be present in the used wash water based on the operating record. The analytical results from these samples will be used to provide baseline data for decontamination verification. Analytical procedures will conform to methods found in the most current version of "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" (*SW-846*) (U.S. Environmental Protection Agency [EPA], 1986). Used wash water will also be analyzed for the same parameters. Used wash water will be considered contaminated it shows a significant increase (i.e., determined using statistical methods defined in *SW-846*) in the analytical parameters over the clean wash water solution. If subsequent washdowns are deemed necessary, an additional sample of clean wash water will be taken for each additional washdown event.

Successful decontamination meets one of the following criteria:

- No detectable RCRA-regulated constituent residues from the management of authorized RCRA-regulated wastes are identified in samples collected during closure activities.
- Analytical results of samples collected during closure activities identify no statistically significant concentrations of RCRA-regulated constituents above baseline data.
- Detectable concentrations of RCRA-regulated constituents in samples collected during closure activities are at or below levels agreed upon with the NMED to be protective of human health and the environment based on the results of risk assessment methods.
- Detectable concentrations of RCRA-regulated constituents that cannot be removed or decontaminated to acceptable levels as described above will be allowed to remain provided that these RCRA-regulated constituents do not pose an unacceptable risk when combined with technical or administrative control measures agreed upon with the NMED.

An alternative demonstration of decontamination may be proposed and justified at the time of unit closure as circumstances indicate. The NMED will evaluate the proposed alternative in accordance with the standards and guidance then in effect and, if approved, incorporate the alternative into this closure plan.

E.2.7 CLOSURE SCHEDULE [20 NMAC 4.1, Subpart V, 264.112(b)(6) and 264.113]

Closure activities will begin in accordance with the approved closure plan, as required by 20 NMAC 4.1, Subpart V, 264.113(a) [1-1-97], within 90 days after final receipt of evaporator bottoms solutions waste at the vitrification unit slab tanks. This timeframe will be met as long as facilities are available for disposal of the treated vitrified waste. In the event that closure activities cannot be completed at the vitrification unit slab tanks within 90 days, LANL will notify the Secretary of the NMED in accordance with the extension requirements cited in 20 NMAC 4.1, Subpart V, 264.113(a) [1-1-97]. Closure activities and reporting requirements will be completed within 180 days of the receipt of the final volume of evaporator bottoms solutions waste at the vitrification unit slab tanks. Closure will be conducted in accordance with the schedule presented in Table E.2-2 of this closure plan. In the event that closure of the vitrification unit slab tanks is prevented from proceeding according to schedule, LANL will notify the Secretary of the NMED in accordance with extension request requirements in 20 NMAC 4.1, Subpart V, 264.113(b) [1-1-97]. In addition, the demonstrations in 20 NMAC 4.1, Subpart V, 264.113(a)(1) and (b)(1) [1-1-97], will be made in accordance with 20 NMAC 4.1, Subpart V, 264.113(c) [1-1-97].

E.2.8 CLOSURE CERTIFICATION [20 NMAC 4.1, Subpart V, 264.115]

Within 60 days after completion of closure activities for the vitrification unit slab tanks, the U.S. Department of Energy (DOE) will submit to the Secretary of the NMED, via certified mail, a certification that the vitrification unit slab tanks have been closed in accordance with the specifications of the closure plan. The certification will be attested to by an independent, registered professional engineer and will be signed by the appropriate DOE and LANL officials, in accordance with 20 NMAC 4.1, Subpart V, 264.115 [1-1-97]. Documentation supporting the independent registered engineer's certification will be furnished to the Secretary of the NMED with the original certification. A copy of the certification and supporting documentation shall be maintained by both the DOE/Los Alamos Area Office and LANL's Hazardous and Solid Waste Group.

E.2.9 SAMPLING AND ANALYTICAL PROCEDURES [20 NMAC 4.1, Subpart V, 264.112(b)(4)]

The following sections describe procedures and methods for sampling, analysis, and documentation applicable to decontamination activities. While the procedures and methods are specific, other applicable procedures or methods given in *SW-846* may be used if conditions or experience show the alternate method to be more appropriate. All sampling and analytical procedures actually used will be annotated in the final closure report. Sampling will be conducted in accordance with procedures given in *SW-846* for hazardous components. All sampling conducted during closure and decontamination will be done in accordance with a written QA/QC plan.

E.2.9.1 Liquid Sampling

A composite liquid waste sampler (COLIWASA) or similar device will be used to sample unused wash water solutions before decontamination begins in order to determine baseline parameters. It will also be used to sample the wash water used in decontaminating the vitrification unit slab tanks. As an alternative to the COLIWASA, glass tubes may be used to sample liquids. The primary advantage in using a glass tube is that the tube will be disposed of appropriately after each sample is collected, thus eliminating the potential for cross contamination.

E.2.9.1.1 Cleaning of Samplers

The sampler must be clean before use. An unused, disposable sampler will be presumed clean if still in a factory-sealed wrapper. Unsealed samplers will be cleaned prior to use. Samplers will be washed with a detergent and water solution, rinsed several times with tap water, rinsed with distilled water, drained of excess water, and air-dried or wiped dry. Clean samplers will be stored in clean polyethylene plastic tubes or bags in a clean and protected area.

E.2.9.1.2 Sampling Procedure

Liquid sampling with a COLIWASA will be performed as follows:

- Ensure that the COLIWASA is clean.
- Assemble the COLIWASA.
- Check that the sampler is functioning properly. Adjust the locking mechanism, if necessary, to make sure the neoprene rubber stopper provides a tight closure.
- Wear necessary protective clothing and gear, and observe required sampling precautions.
- Put the sampler in the open position by placing the stopper-rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
- Slowly lower the COLIWASA into the liquid at a rate that permits the level of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sampler tube is lower than that outside the sampler, the sampling rate is too fast and will result in a nonrepresentative sample.
- When the sampler stopper hits the bottom of the liquid container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
- Slowly withdraw the sampler from the container with one hand, while wiping the sampler tube with a disposable cloth with the other hand.
- Carefully discharge the sample into a sample container by slowly opening the sampler. This is done by slowly pulling the lower end of the T-handle away from the locking block, while the lower end of the sampler is positioned in the sample container.
- Preserve as required (see Table E.2-3), cap the container, attach a label and seal, place immediately in an insulated container with ice (if required), record in the field logbook, and complete the sample analysis request sheet and chain-of-custody form.
- Unscrew the T-handle of the sampler and disengage the locking block. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube or bag for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

E.2.9.2 Sample Handling and Documentation

Samples will be analyzed either at LANL or at a commercial laboratory. In either case, each sample will be labeled, sealed, and accompanied by a chain-of-custody and sample analysis request form. The chain-of-custody form is necessary to trace sample possession from the time of collection to the time of analysis and must accompany every sample. The original record will accompany shipment.

The copy is retained by LANL. If samples are analyzed at LANL, the original will be maintained by LANL. The request for analysis form has two parts: field and laboratory. The field portion of this form will be completed by the person collecting the sample and include most of the pertinent information noted in the logbook. The laboratory portion will be completed by the analytical laboratory personnel when the sample is received. The analytical laboratory retains the original record and sends a copy to LANL.

Sample containers appropriate for the requested analyses will be used for all samples. Sample containers, preservation, and holding times will conform to those specified in *SW-846* for the corresponding analyses. Samples will be collected, placed in bottles, sealed, and tagged. Sample container surfaces will be screened for radiological contamination and decontaminated, if necessary. Sample containers will then be immediately packed in vermiculite, sawdust, or if refrigeration is required, an insulated container with ice. Recommended sample containers, preservation, and holding times are presented in Table E.2-3.

The sample container will be sealed in such a way that the seal must be broken in order to open the container. The seal and sample tag will be completed with a waterproof pen. The sample label will be completed to include the project name, sample number, collection date/time, collector's name, sample location, sample media description, preservative, and analysis requested.

A field logbook will be kept and will contain all information pertinent to field surveys and sampling. Examples of entries include:

- Purpose of sample (closure sampling, special sampling)
- Location of sampling
- Name and business address of person making log entry
- Type of process producing waste
- Number and volume of sample
- Description of each sampling location, sampling methodology, equipment used, etc.
- Date and time of sample collection
- Sample destination and transporter's name (e.g., name of laboratory, United Parcel Service)

- Map or photograph of the sampling site, if any
- Field observations, if applicable
- Field measurements, if applicable (e.g., pH, conductivity)
- Collector's sample identification number(s)
- Signature of person responsible for the log entry.

Because sampling situations vary widely, no specific rule can be given as to the extent of information that must be entered in the logbook. However, sufficient information will be recorded so that someone can reconstruct the sampling situation without relying on the collector's memory.

E.2.10 QUALITY ASSURANCE/QUALITY CONTROL

A qualified individual or individuals will be designated to independently oversee the closure activities and to report directly to senior management on the quality of the closure performance. This individual will personally observe a portion of the key activities, assure that sample blanks are used and analyzed, and review the analysis reports for accuracy and adequacy. A written QA/QC plan prepared in accordance with *SW-846* guidance will be prepared and followed, with variations from the plan documented and explained. The designated individual will prepare a written statement for the final report commenting on the level of decontamination verification achieved.

E.2.11 CLOSURE REPORT

Upon completion of the closure activities for the vitrification unit slab tanks, a closure report will be submitted to the Secretary of the NMED. The report will document the closure and contain a closure certification (see E.2.8), a description of any variances from the approved procedures, a summary of the sampling results, a QA/QC statement, the location of the file of supporting documentation, disposition location of RCRA-regulated closure materials, and a certification of accuracy of the report.

E.2.12 CLOSURE COST ESTIMATE, FINANCIAL ASSURANCE, AND LIABILITY REQUIREMENTS [20 NMAC 4.1, Subpart V, 264.140(c)]

In accordance with 20 NMAC 4.1, Subpart V, 264.140(c) [1-1-97], LANL, as a federal facility, is exempt from the requirements of 20 NMAC 4.1, Subpart V, Part 264, Subpart H [1-1-97], to provide a cost estimate, financial assurance mechanisms, and liability insurance for closure actions.

E.2.13 SURVEY PLAT AND POST-CLOSURE REQUIREMENTS [20 NMAC 4.1, Subpart V, 264.116 and 264.117 through 264.120]

It is the intent of LANL to either remove hazardous and mixed waste constituents from the vitrification unit slab tanks and to decontaminate all surfaces and equipment to established cleanup levels or to decommission or dismantle and dispose of the contaminated surfaces and equipment. LANL will amend this closure plan, as necessary, to address changes to closure procedures or post-closure care requirements pursuant to 20 NMAC 4.1, Subpart V, 264.117 through 264.120 [1-1-97]. A survey plat, post-closure certification, and post-closure notices will not be required because, subject to this closure plan, unless amended, all waste will be removed and the vitrification unit slab tanks will be decontaminated or disposed of at closure. Therefore, these requirements are not applicable.

E.2.13 AMENDMENT OF PLAN [20 NMAC 4.1, Subpart V, 264.112(c)]

In accordance with 20 NMAC 4.1, Subpart IX, 264.112(c) [1-1-97], LANL will submit a written notification of or request for a permit modification to authorize a change in the approved closure plan whenever:

- There are changes in operating plans or facility design that affect the closure plan
- There is a change in the expected year of closure
- Unexpected events occur during closure that require modification of the approved closure plan.

The written notification or request will include a copy of the amended closure plan for approval by the NMED.

LANL will submit a written request for a permit modification with a copy of the amended closure plan at least 60 days prior to the proposed change in unit design or operation or no later than 60 days after an occurrence of an unexpected event that affects the closure plan. If the unexpected event occurs during closure, the permit modification will be requested within 30 days of the occurrence. If the Secretary of the NMED requests a modification of the closure plan, a plan modified in accordance with the request will be submitted within 60 days of notification or within 30 days of notification if a change in facility condition occurs during the closure process.

E.2.14 REFERENCES

EPA, 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.

Table E.2-1

Analytical Parameters and Test Methods[a]

Parameter	Test Method	Reference
Corrosivity	Electrometric (pH of aqueous solution)	SW-846 (9040B)[b] or equivalent methods
TC Metals:	Atomic absorption,	SW-846
Arsenic	Furnace technique,	(3010A, 6010B, 7060A[c], 7061A)[b]
Barium	Gaseous hydride,	(3010A, 6010B, 7080A[d], 7081[c])[b]
Cadmium	Direct aspiration, and	(3010A, 6010B, 7130[d], 7131A[c])[b]
Chromium	Borohydride reduction	(3010A, 6010B, 7190[d], 7191[c])[b]
Lead	Acid Digestion	(3010A, 6010B, 7420[d], 7421[c])[b]
Silver	Inductively coupled plasma atomic emission spectroscopy	(3010A, 6010B, 7760A[d], 7761[c])[b]
TC Mercury	Manual cold-vapor technique	(3010A, 6010B, 7470A) or equivalent methods

[a] At Los Alamos National Laboratory, current analytical capabilities include limited analyses of mixed transuranic waste samples. These analyses include, but are not limited to, gross alpha, beta, and gamma screening.
[b] U.S. Environmental Protection Agency, 1986 and all approved updates "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846*, Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.
[c] Method being integrated into Method 7000B, per the January 1998 SW-846 Draft Update IV A.
[d] Method being integrated into Method 7010, per the January 1998 SW-846 Draft Update IV A.

TC = toxicity characteristic

Table E.2-2

Closure Schedule for the Technical Area 55 Vitrification Unit Slab Tanks

Activity	Maximum Time Required[a]
Let contract request for proposals	-90 Days
Notify the New Mexico Environment Department (NMED)	-45 Days
Receive proposals	-30 Days
Select contractor and award contract	-10 Days
Removal of final waste volume	Day 5
Perform washdown of vitrification unit slab tanks, collect samples from wash water, submit samples, for analyses	Day 15
Receive analyses on samples	Day 45
Perform additional washdown (if necessary)	Day 50
Perform additional sampling and submit samples for analyses (if necessary)	Day 50
Receive analyses on samples from additional sampling	Day 80
Equipment disassembly	Day 100
Perform final cleanup (e.g., removal of decontaminated equipment and decontamination wastes)	Day 110
Verify decontamination	Day 125
Submit final report to the NMED	Day 180

[a] The schedule above indicates calendar days from the beginning by which activities will be completed. Some activities may be conducted simultaneously.

Table E.2-3
Sample Containers, Preservation, and Holding Times[a]

Analyte Group	Container[b]	Preservative	Holding Time[c]
TC Metals Arsenic Barium Cadmium Chromium Lead Silver	600 ml P or G	HNO_3 to pH <2	180 days
Mercury	400 ml P or G	HNO_3 to pH <2; cool to 4°C	28 days

[a] Holding time information was taken from U.S. Environmental Protection Agency (EPA), 1986 and all approved updates, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," *EPA-SW-846,* Office of Solid Waste and Emergency Response, U.S. Government Printing Office, Washington, D.C.

[b] Smaller sample containers may be required due to health and safety concerns associated with potential radiation exposure, transportation requirements, and waste management considerations.

[c] Holding time from when the sample is taken.

°C = degrees Celsius
G = Glass
HNO_3 = Nitric acid
ml = milliliters
P = Polyethylene
TC = Toxicity characteristic

801448 TA-55 Vit A3

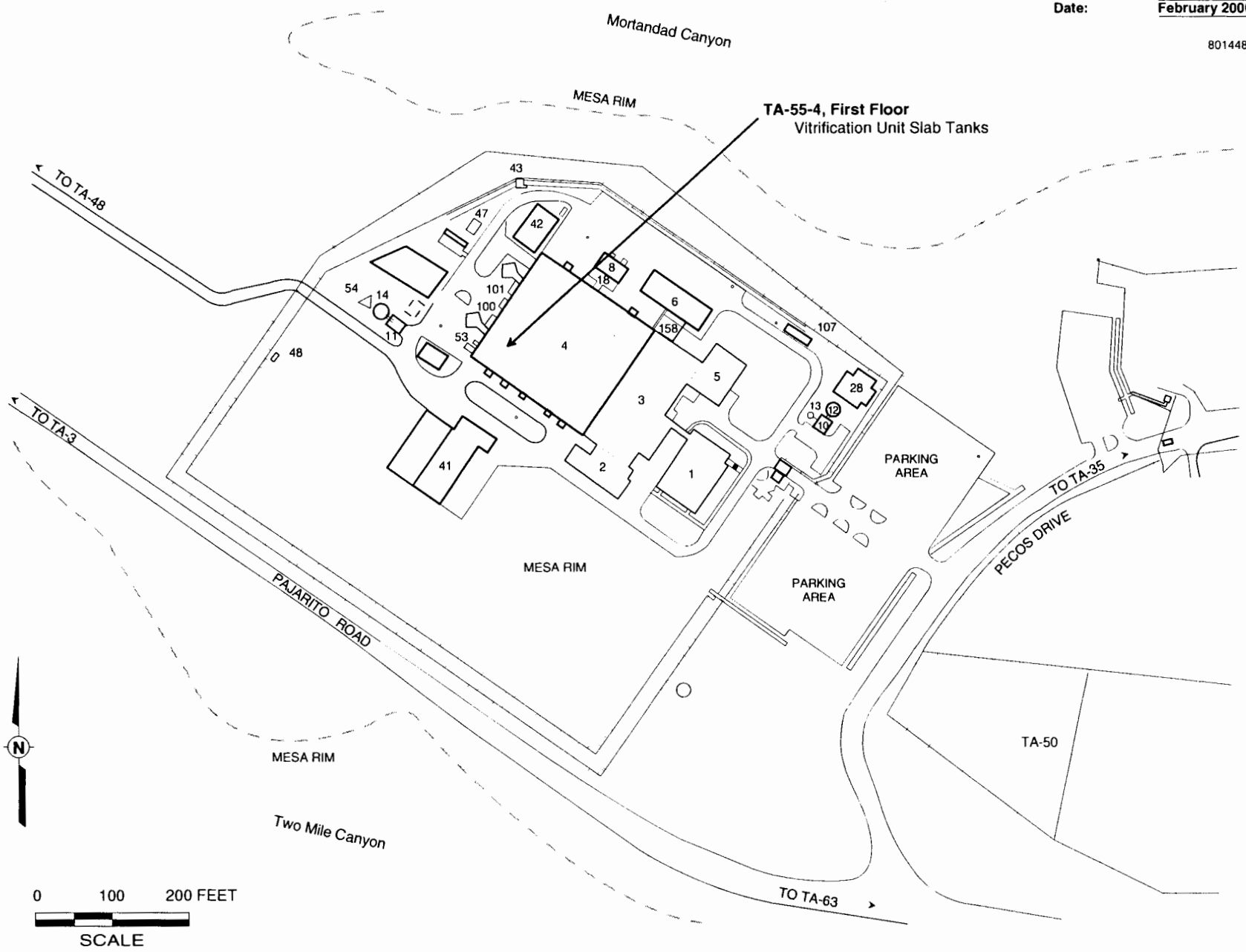

Figure E.2-1
Technical Area (TA) 55 Vitrification Unit Slab Tanks

CONTAINER MANAGEMENT

PERMIT ATTACHMENT F
NM0890010515-1

ATTACHMENT F
CONTAINER MANAGEMENT

Attachment F of the permit describes container management procedures. Neither the vitrification unit nor the vitrification unit slab tanks will involve the management of containers. Therefore, no changes or additions are proposed to this attachment of the permit.

AUTHORIZED WASTES

PERMIT ATTACHMENT G
NM0890010515-1

EPA I.D. Number *(Enter from Page 1)* Secondary ID Number *(Enter from Page 1)*

NM0890010515

XIV. Description of Hazardous Wastes *(Continued)*

Line Number	A. EPA Hazardous Waste No. (enter code)	B. Estimated Annual Quantity of Waste *	C. Unit of Measure (Enter code)	D. PROCESSES (1) PROCESS CODES (Enter code)			(2) PROCESS DESCRIPTION (If a code is not entered in D(1))
Technical Area 55							
1	D002	70,000	P	S02	T04		Mixed Transuranic Waste (MTRUW)
2	D004	2,000	P	S02	T04		MTRUW
3	D005	5,000	P	S02	T04		MTRUW
4	D006	200,000	P	S02	T04		MTRUW
5	D007	300,000	P	S02	T04		MTRUW
6	D008	400,000	P	S02	T04		MTRUW
7	D009	10,000	P	S02	T04		MTRUW
8	D011	5,000	P	S02	T04		MTRUW

* Estimated annual quantities show are the total for MTRUW with these EPA Hazardous Waste Nos. at TA-55. The wastes stored in the vitrification unit slab tanks and treated in the vitrification unit are a subset of these quantities.

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Dennis J. Erickson
Division Director for Environment, Safety, and Health Division
Los Alamos National Laboratory
Operator

2/25/00
Date Signed

David A. Gurulé, P.E.
Area Manager, Los Alamos Area Office
U.S. Department of Energy
Albuquerque Operations
Owner/Operator

2/25/00
Date Signed

Document:	**Supplemental Information Document for the TA-55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request**
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Date:	**February 2000**

Supplemental Information Document for the Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request

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1	"Glass Development for Treatment of LANL Evaporator Bottoms Waste," *PNNL-11865 UC-510*, Pacific Northwest National Laboratory, Richland, Washington
2	Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks

LIST OF ABBREVIATIONS/ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BPVC	Boiler and Pressure Vessel Code
CAM	continuous air monitor
CAS	Central Alarm Station
40 CFR	Title 40 of the Code of Federal Regulations
cm/hr	centimeters per hour
°C	degrees Celsius
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FMCS	facility monitor/control system
ft	foot (feet)
HEPA	high-efficiency particulate air
HP	horsepower
in.	inch(es)
INEEL	Idaho National Engineering and Environmental Laboratory
JCI	Johnson Controls World Services, Inc.
L	liter(s)
LACFD	Los Alamos County Fire Department
LANL	Los Alamos National Laboratory
mg/L	milligrams per liter

LIST OF ABBREVIATIONS/ACRONYMS (continued)

NAAQS	National Ambient Air Quality Standards
20 NMAC 4.1	New Mexico Administrative Code, Title 20, Chapter 4, Part 1
NMED	New Mexico Environment Department
NMAAQS	New Mexico Ambient Air Quality Standards
O.D.	outer diameter
PA	public address
pCi/g	picoCuries per gram
PNNL	Pacific Northwest National Laboratory
PTLA	Protection Technology Los Alamos
Pu	plutonium
RCRA	Resource Conservation and Recovery Act
SWMU	solid waste management unit
TA	technical area
TC	toxicity characteristic
TCLP	Toxicity Characteristic Leaching Procedure
TRU	transuranic
USC	United States Code
UTS	Universal Treatment Standard
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This document provides supplemental information to the "Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request," hereinafter referred to as the permit modification request. This supplemental information document has been prepared for submittal to the New Mexico Environment Department and addresses the applicable miscellaneous unit and tank system requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.23 and 270.16, and 20 NMAC 4.1, Subpart V, Part 264, Subparts X and J, revised January 1, 1997 [1-1-97]. This document also addresses the applicable general Part B permit application requirements of 20 NMAC 4.1, Subpart IX, 270.14 and 20 NMAC 4.1, Subpart V, Part 264, Subparts B, C, E, and F [1-1-97]. Pursuant to 20 NMAC 4.1, Subpart IX, 270.42(c)(1)(ii) [1-1-97], Los Alamos National Laboratory (LANL) is requesting a Class 3 permit modification to their existing Hazardous Waste Facility Permit, ID Number NM0890010515, issued by the New Mexico Health and Environment Department Environmental Improvement Division in 1989, to install and operate the vitrification unit and the vitrification unit slab tanks. As required by 20 NMAC 4.1, Subpart IX, 270.42(b)(1)(i) [1-1-97], the exact changes to be made to the permit conditions and supporting documents referenced by the permit are described in Table 1-1. Pursuant to 20 NMAC 4.1, Subpart IX, 270.42(b)(1)(iii) [1-1-97], this permit modification is needed to provide LANL with the ability to effectively treat the evaporator bottoms solutions waste, a mixed transuranic waste, generated at Technical Area (TA) 55.

This document provides information for the vitrification unit and vitrification unit slab tanks to be installed at TA-55, Building 4, Room 434A, inside Room 401. It includes a description of the facility, a discussion of waste management practices, detailed descriptions of the vitrification unit and vitrification unit slab tanks, and a demonstration of treatment effectiveness. This document also includes information on compliance with environmental performance standards for the vitrification unit, a written engineering assessment/certification for the vitrification unit slab tanks, and information on special requirements for ignitable/reactive/incompatible wastes, air emission standards, and recordkeeping requirements. A description of corrective actions for solid waste management units and compliance with other federal laws is also presented in this document.

The vitrification unit will be used to vitrify or stabilize evaporator bottoms solutions waste generated at TA-55. The vitrification unit slab tanks will be used to store evaporator bottoms solutions waste prior to treatment in the vitrification unit. Figure 1-1 shows the general arrangement of the vitrification unit and vitrification unit slab tanks and is provided for informational purposes only. This

figure is provided under separate cover to comply with Unclassified Controlled Nuclear Information procedures.

Table 1-2 provides a list of regulatory references and the corresponding location in this supplemental information document or in the permit modification request. Where applicable, regulatory citations in this supplemental information document and the permit modification request adopt, with a few limited exceptions, Title 40 of the Code of Federal Regulations, Parts 260 to 266, Part 268, Part 270, and Part 273.

Table 1-1

Summary of Changes to be Made to Permit Conditions

Permit Section	Requested Change
Module I	Not applicable; no changes needed.
Module II	Not applicable; no changes needed.
Module III	Not applicable; no changes needed.
Module IV	Not applicable; no changes needed.
Module V	Not applicable; no changes needed.
Module VI	Not applicable; no changes needed.
Module VII	Not applicable; no changes needed.
Module VIII	Not applicable; no changes needed.
Module	Provided proposed permit module for the Vitrification Unit.
Module	Provided proposed permit module for the Vitrification Unit Slab Tanks.
Figure	Provided figure showing the location of the Vitrification Unit and Vitrification Unit Slab Tanks.
Attachment A	Provided Waste Analysis Plan for the Vitrification Unit and Vitrification Unit Slab Tanks.
Attachment B	Provided Inspection Plan for the Vitrification Unit and Vitrification Unit Slab Tanks to supplement the "Inspection Plan" submitted to the New Mexico Environment Department (NMED) as a permit modification request dated November 19, 1999[a].
Attachment C	Provided Personnel Training for the Vitrification Unit and Vitrification Unit Slab Tank to supplement the "Personnel Training Plan" submitted to the NMED as a permit modification request dated November 19, 1999[a].
Attachment D	Provided Contingency Plan for the Vitrification Unit and Vitrification Unit Slab Tanks to supplement the "Contingency Plan" submitted to the NMED as a permit modification request dated November 19, 1999[a].
Attachment E	Provided Closure Plans for the Vitrification Unit (Attachment E.1) and Vitrification Unit Slab Tanks (Attachment E.2).
Attachment F	Not applicable; no changes needed.

See footnotes at end of table.

Table 1-1 (Continued)

Summary of Changes to be Made to Permit Conditions

Permit Section	Requested Change
Attachment G	Provided table of authorized wastes for the Vitrification Unit and the Vitrification Unit Slab Tanks.
Attachment H	Not applicable; no changes needed.
Attachment I	Not applicable; no changes needed.
Attachment J	Not applicable; no changes needed.
Attachment K	Not applicable; no changes needed.
Attachment L	Not applicable; no changes needed.

[a] LANL, 1999, "Los Alamos National Laboratory General Part B Plans Permit Modification Request," Revision 1.1, November 19, 1999, Los Alamos National Laboratory, Los Alamos, New Mexico.

Table 1-2

Regulatory References and Corresponding Location

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§270.14(b)(1)	General facility description	2.0
§270.14(b)(2)	Chemical and physical analyses of hazardous waste	Attachment A[a]
§270.14(b)(3)	Waste analysis plan	Attachment A[a]
§264.13(b)	Development and implementation of a written waste analysis plan	Attachment A[a]
§264.13(c)	Off-site waste analysis requirements	NA[b]
§264.14	Security	3.0
§270.14(b)(4)	Security procedures and equipment	3.0
§270.14(b)(5)	General inspection schedule	Attachment B[a]
§264.15(b)	General inspection requirements	Attachment B[a]
§264.174	Inspections/containers	NA
§264.193(i)	Tank system inspections pending provision of adequate secondary containment	NA
§264.195	Overfill control inspections	Attachment B[a]
§264.226	Surface impoundment monitoring and inspection	NA
§264.254	Waste pile monitoring and inspection	NA
§264.273	Land treatment design and operating requirements	NA
§264.303	Landfill monitoring and inspection	NA
§264.347	Incineration monitoring and inspection	NA
§264.602	Miscellaneous units	4.0
§264.1033	Process vent standards	NA
§264.1052	Equipment leak air emission standards	4.0, 5.0
§264.1053	Compressor standards	4.0, 5.0
§264.1058	Standards for pumps, valves, pressure relief devices, flanges, and connections	4.0, 5.0
§264.1088	Subpart CC inspection and monitoring requirements	NA
§270.14(b)(6)	Request for waiver from preparedness and prevention requirements of 264 Subpart C	NA
§270.14(b)(7)	Contingency plan requirements under 264 Subpart D	Attachment D[a]
§264, Subpart D	Contingency plan and emergency procedures	Attachment D[a]
§264.277	Surface impoundment emergency repairs; contingency plans	NA

See footnotes at end of table.

Table 1-2 (continued)

Regulatory References and Corresponding Location

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§270.14(b)(11)(ii)(B)	If faults which have displacement in Holocene time are present within 3,000 ft, no faults pass within 200 ft of portions of the facility where treatment, storage, or disposal will be conducted	NA
§270.14(b)(11)(iii)	100-year floodplain standard	2.0
§270.14(b)(11)(iv)	Facilities located within the 100-year floodplain	NA
§270.14(b)(11)(v)	Compliance schedule for 264.18(b)	NA
§270.14(b)(12)	Personnel training program	Attachment C[a]
§270.14(b)(13)	Closure and post-closure plans	Attachment E.1[a], Attachment E.2[a]
Subpart G	Closure and post-closure	Attachment E.1[a], Attachment E.2[a]
§264.178	Closure/containers	NA
§264.197	Closure and post-closure care/tanks	Attachment E.2[a]
§270.14(b)(14)	Post-closure notices (264.119)	Attachment E.1[a], Attachment E.2[a]
§270.14(b)(15)	Closure cost estimate (264.142)	Attachment E.1[a], Attachment E.2[a]
§270.14(b)(16)	Post-closure cost estimate (264.144)	Attachment E.1[a], Attachment E.2[a]
§270.14(b)(17)	Liability insurance (264.147)	NA
§270.14(b)(18)	Proof of financial coverage (264.149-150)	NA
§270.14(b)(19)	Topographic map requirements	2.0
§270.14(b)(19)(i)	Map scale and date	2.0
§270.14(b)(19)(ii)	100-year floodplain area	2.0
§270.14(b)(19)(iii)	Surface waters	2.0
§270.14(b)(19)(iv)	Surrounding land uses	2.0
§270.14(b)(19)(v)	Wind rose	2.0
§270.14(b)(19)(vi)	Map orientation	2.0

See footnotes at end of table.

Table 1-2 (continued)

Regulatory References and Corresponding Location

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§270.14(b)(11)(ii)(A)(4)	Reconnaissance based on walking portions of the area within 3,000 ft of the facility	2.0
§270.14(b)(11)(ii)(B)	If faults which have displacement in Holocene time are present within 3,000 ft, no faults pass within 200 ft of portions of the facility where treatment, storage, or disposal will be conducted	NA
§270.14(b)(11)(iii)	100-year floodplain standard	2.0
§270.14(b)(11)(iv)	Facilities located within the 100-year floodplain	NA
§270.14(b)(11)(iv)(A)	Engineering analysis of hydrostatic forces expected in 100-year flood	NA
§271.14(b)(11)(iv)(B)	Structural engineering studies for flood protection to prevent washout	NA
§270.14(b)(11)(iv)(C)	Detailed description of procedures to remove hazardous waste to safety before flood reaches the waste	NA
§270.14(b)(11)(iv)(C)(1)	Timing of removal	NA
§270.14(b)(11)(iv)(C)(2)	Location to be moved to	NA
§270.14(b)(11)(iv)(C)(3)	Dedicated equipment and personnel to ensure removal	NA
§270.14(b)(11)(iv)(C)(4)	Potential for accidental discharge during movement	NA
§270.14(b)(11)(v)	Compliance schedule for 264.18(b)	NA
§270.14(b)(12)	Personnel training program	Attachment C[a]
§270.14(b)(13)	Closure and post-closure plans	Attachment E.1[a], Attachment E.2[a]
§264.112	Amendment of closure plan	Attachment E.1[a], Attachment E.2[a]
§264.118	Post-closure plan; amendment of plan	Attachment E.1[a], Attachment E.2[a]
§264.197	Closure and post-closure care/tanks	Attachment E.2[a]
§264.601	Miscellaneous units	4.0
§264.603	Post-closure care	Attachment E.1[a]
§270.14(b)(14)	Post-closure notices (264.119)	Attachment E.1[a], Attachment E.2[a]

See footnotes at end of table.

Figure 1-1 has been provided confidentially under separate cover.

2.0 FACILITY DESCRIPTION

This information is provided in accordance with the applicable requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), revised January 1, 1997 [1-1-97]. The following subject areas are addressed:

- A general description of Technical Area (TA) 55 at Los Alamos National Laboratory (LANL) [20 NMAC 4.1, Subpart IX, 270.14(b)(1)];
- Site-specific traffic patterns, volume, and control [20 NMAC 4.1, Subpart IX, 270.14(b)(10)];
- Site-specific location information for compliance with the seismic standard and floodplain requirements [20 NMAC 4.1, Subpart IX, 270.14(b)(11) and 20 NMAC 4.1, Subpart V, 264.18(a) and (b)];
- Site-specific topographic map requirements [20 NMAC 4.1, Subpart IX, 270.14(b)(19)]; and
- Site-specific groundwater monitoring and protection information [20 NMAC 4.1, Subpart IX, 270.14(c) and 20 NMAC 4.1, Subpart V, 264.90(a)].

2.1 TA-55 GENERAL DESCRIPTION [20 NMAC 4.1, Subpart IX, 270.14(b)(1)]

TA-55 is located in the north central portion of LANL (Figure 2-1) on a finger mesa between a branch of Mortandad Canyon on the north and Two Mile Canyon on the south. Mesa-top elevations at TA-55 range from approximately 7,100 to 7,300 feet (ft) above mean sea level. The proposed location of the vitrification unit and vitrification unit slab tanks at TA-55 is shown on Figure 2-2.

TA-55 is a plutonium processing facility, which began operating in 1978. Plutonium processing and related activities occur in TA-55, Building 4 (TA-55-4), which is the largest building at TA-55. The vitrification unit and vitrification unit slab tanks will be located on the first floor of TA-55-4 (Figure 2-2).

2.2 TRAFFIC PATTERNS [20 NMAC 4.1, Subpart IX, 270.14(b)(10)]

The following provides information on routes of travel, traffic volumes, traffic control signals, and road load-bearing capacity at TA-55.

2.2.1 Routes of Travel

Mixed transuranic waste to be treated/stored in the vitrification unit/vitrification unit slab tanks at TA-55 is generated at TA-55. Mixed waste is occasionally transported from TA-55 to other areas at

LANL (e.g., TA-54). The primary traffic routes that may be used to transport mixed waste to and from TA-55 include Diamond Drive, Pajarito Road, and Pecos Drive (Figure 2-3).

2.2.2 Traffic Volumes

The buildings at TA-55 are located northwest of the intersection of Pajarito Road and Pecos Drive, as shown on Figure 2-4. According to a traffic study conducted by Johnson Controls World Services, Inc. (JCI) (JCI, 1999), Pajarito Road has an average daily traffic volume of 12,000 vehicles per day. This includes vehicles traveling both northwest and southeast. Pecos Drive has an average daily traffic volume of 5,000 vehicles per day. This includes vehicles traveling both north and south. These values are based on a 24-hour period. Vehicle types include cars, light- and medium-duty trucks, and vans.

2.2.3 Traffic Control Signals

Traffic control signals within TA-55 include stop signs, posted speed limits, traffic lights, and other traffic and pedestrian control signs. The locations of existing traffic control signals at TA-55 are shown on Figure 2-4.

2.2.4 Road Load-Bearing Capacity

Roads within TA-55 are generally two lane roads with asphaltic concrete surfaces. Load-bearing capacity for these roads is 32,000 pounds per axle. These roads are typically constructed with a 6-inch (in.) thick base with a 3-in. thick asphaltic concrete surface. These roads were designed and constructed to meet the American Association of State Highway and Transportation Officials (AASHTO) specification HS-20 (AASHTO, 1996).

2.3 LOCATION INFORMATION [20 NMAC 4.1, Subpart IX, 270.14(b)(11)]

2.3.1 Seismic Standard [20 NMAC 4.1, Subpart IX, 270.14(b)(11)(i - ii); 20 NMAC 4.1, Subpart V, 264.18(a)]

TA-55 is in compliance with the seismic standards of 20 NMAC 4.1, Subpart IX, 270.14(b)(11) and 20 NMAC 4.1, Subpart V, 264.18(a) [1-1-97]. A geologic field investigation, which consisted of exploratory trenching, was conducted within 3,000 ft of TA-55-4 during the fall of 1992 and summer of 1993. Based on trench stratigraphy, no evidence of Holocene faulting was observed (Woodward-Clyde Federal Services, 1995).

2.3.2 Floodplain Standard [20 NMAC 4.1, Subpart IX, 270.14(b)(11)(iii - v) and 270.14(b)(19)(ii); 20 NMAC 4.1, Subpart V, 264.18(b)]

In accordance with 20 NMAC 4.1, Subpart IX, 270.14(b)(11)(iii) [1-1-97], the vitrification unit and vitrification unit slab tanks will not be located within the 100-year floodplain boundary. LANL has mapped all 100-year floodplain boundaries within the LANL complex, as required in "Module VIII: Special Conditions Pursuant to the 1984 Hazardous and Solid Waste Amendments to RCRA for Los Alamos National Laboratory EPA I.D. NM0890010515" (EPA, 1994).

2.4 TOPOGRAPHIC MAPS [20 NMAC 4.1, Subpart IX, 270.14(b)(19)]

Topographic maps and figures are provided herein to meet the requirements of 20 NMAC 4.1, Subpart IX, 270.14(b)(19) [1-1-97]. All maps clearly show the map scale, the date of preparation, and a north arrow. The maps and figures used to fulfill these regulatory requirements include the following:

- A contour map showing surface waters, including intermittent streams, near TA-55 is included as Figure 2-5.
- Surrounding land uses are shown on Figure 2-1.
- Wind roses for TA-6, the TA adjacent to and west of TA-55, are shown on Figures 2-6 and 2-7.
- Access control features at TA-55 (e.g., fences, gates) are shown on Figure 2-8.
- A contour map showing supply wells, monitoring wells, test wells, springs, and surface water sampling stations near TA-55 is included as Figure 2-5.
- The locations of buildings and of the vitrification unit and vitrification unit slab tanks at TA-55 are shown on Figures 2-2 and 2-5.
- Drainage control features (e.g., runoff) are shown on Figure 2-9.
- Natural surface drainages are shown on a topographic map included herein as Figure 2-5.
- A LANL-wide 100-year floodplain map is provided as Figure 2-10.
- A map showing the legal boundaries of LANL (including TA-55) is provided as Figure 2-11.
- A map showing National Pollutant Discharge Elimination System discharge structure locations is included as Figure 2-12.
- Storm, sanitary, and process sewer systems at LANL are shown on Figure 2-13.

- Fire stations serving LANL and the County of Los Alamos are shown on Figure 2-14.
- The equipment cleanup area for LANL is located at TA-50-1. The location of TA-50-1 is shown on Figure 2-15.

Contour lines on the topographic map are in intervals sufficient to detail natural drainage at LANL and at TA-55, Building 4. As provided in 20 NMAC 4.1, Subpart IX, 270.14(b)(19) [1-1-97], LANL has submitted the maps to the New Mexico Environment Department at these scales and contour intervals due to the extent of the LANL facility and the topographic relief in the area.

2.5 GROUNDWATER MONITORING [20 NMAC 4.1, Subpart IX, 270.14(c) and 20 NMAC 4.1, Subpart V, 264.90(a)]

Requirements for groundwater monitoring and protection specified in 20 NMAC 4.1, Subpart IX, 270.14(c), and 20 NMAC 4.1, Subpart V, 264.90(a) [1-1-97], apply to owners and operators of the following "regulated units" only: surface impoundments, waste piles, land treatment units, and landfills. Any units subject to permitting requirements that have associated groundwater monitoring requirements are included in the "Hydrogeologic Workplan," approved by the NMED on March 25, 1998 (LANL, 1998a).

2.6 OTHER PERMIT ACTIVITIES

Other types of Resource Conservation and Recovery Act (RCRA) permits include, but are not limited to, the following:

- Permits by Rule
- Emergency Permits
- Hazardous Waste Incinerator Permits
- Permits of Land Treatment Demonstrations Using Field Test or Laboratory Analyses
- Interim Permits for Underground Injection Control Program Wells
- Research, Development, and Demonstration Permits
- Permits for Boilers and Industrial Furnaces Burning Hazardous Waste

Currently, none of these permit types are relevant to operations at TA-55.

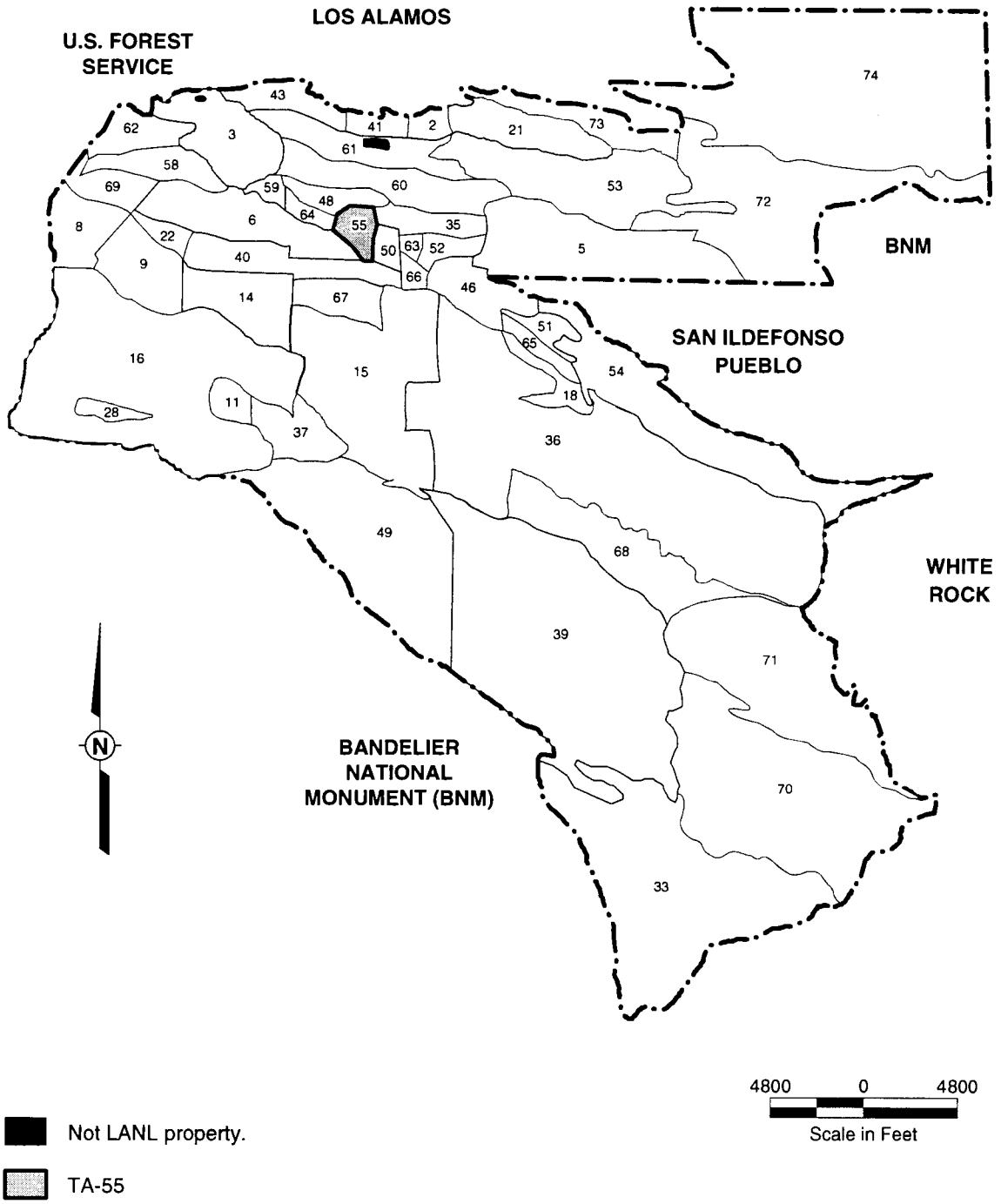


Figure 2-1
Location Map of Technical Area (TA) 55 Los Alamos National Laboratory (LANL)

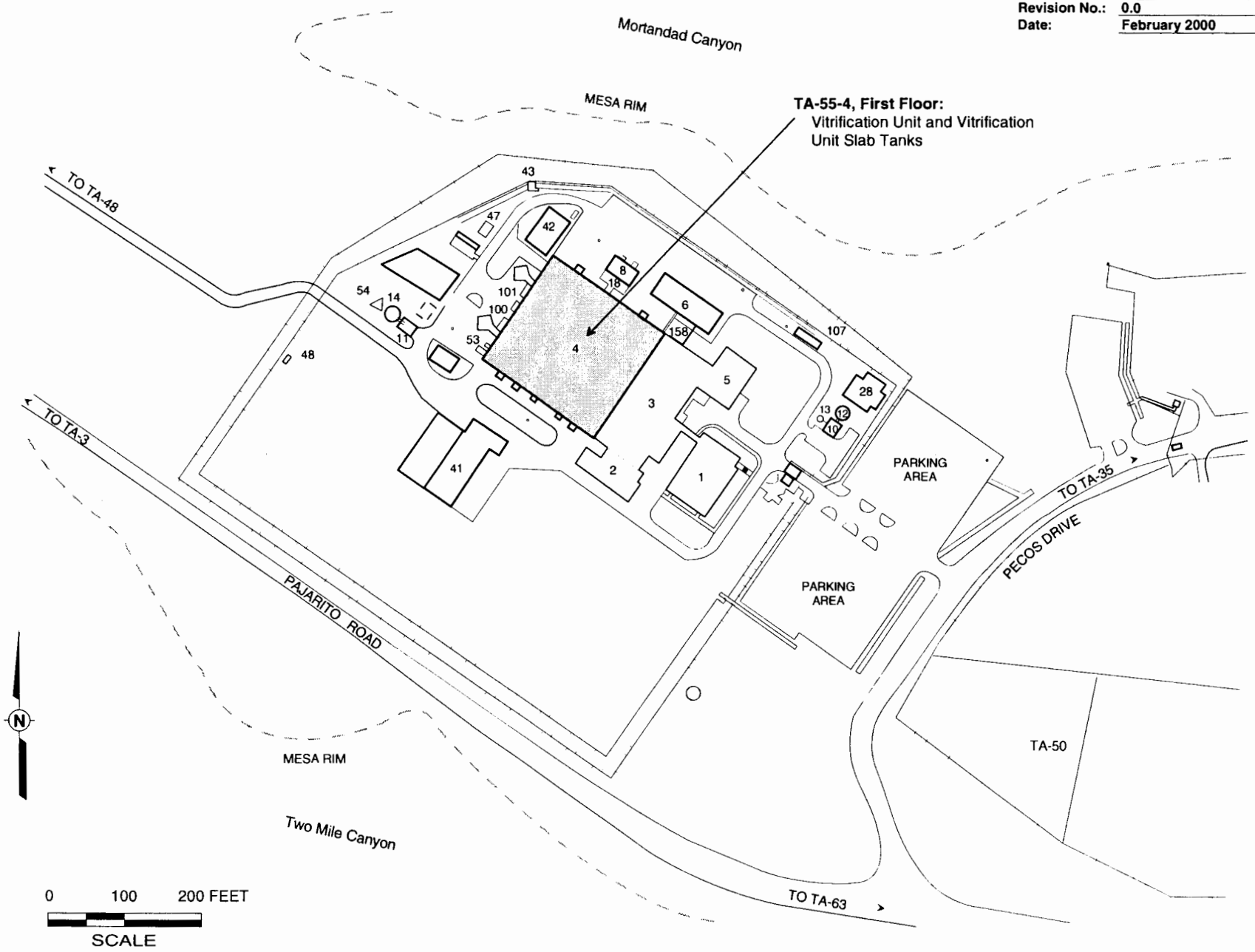


Figure 2-2

Location of the Vitrification Unit and Vitrification Unit Slab Tanks at Technical Area (TA) 55

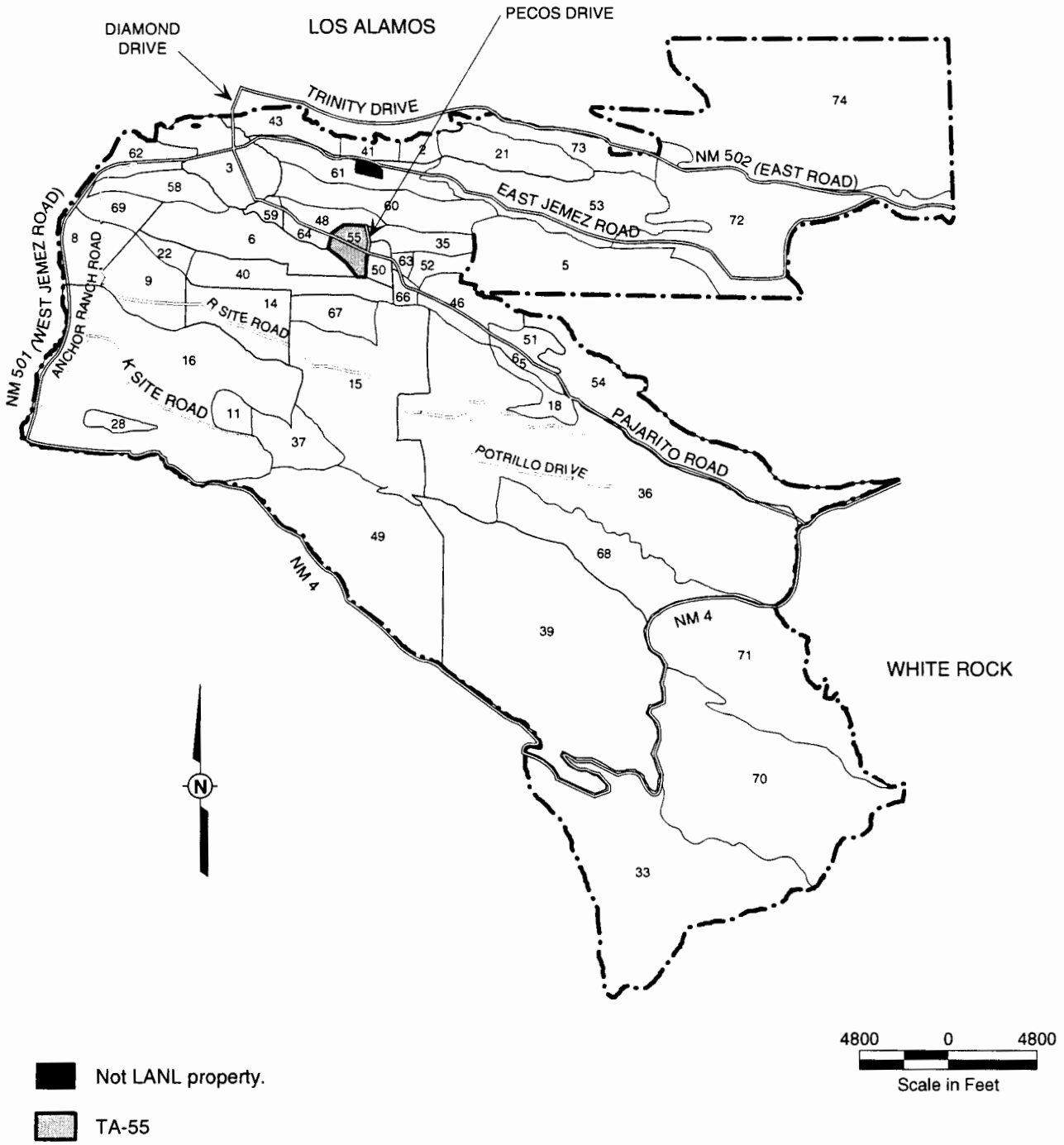


Figure 2-3

Major Roads and Primary Traffic Routes at Los Alamos National Laboratory (LANL)

801448 TA-55 Vit

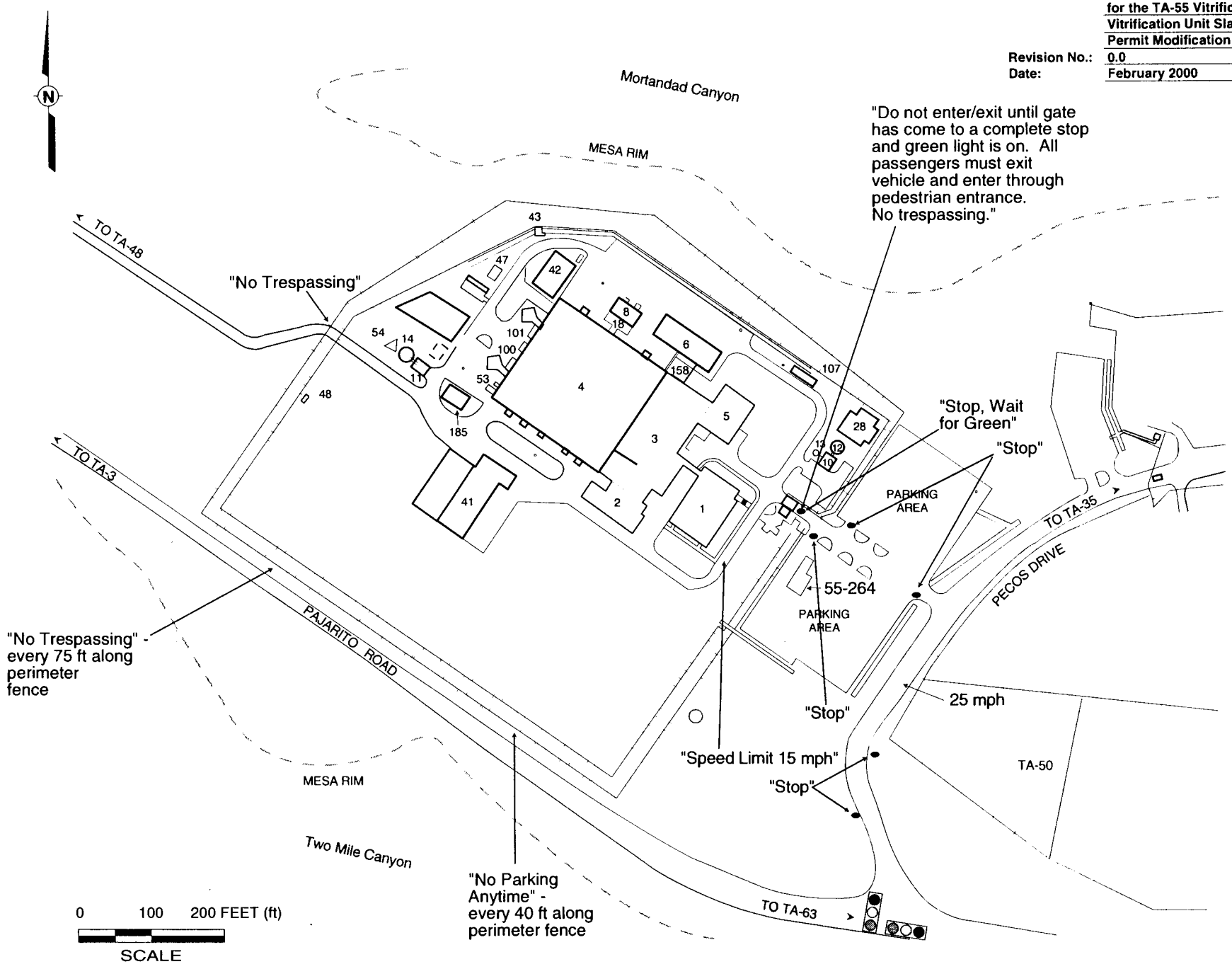
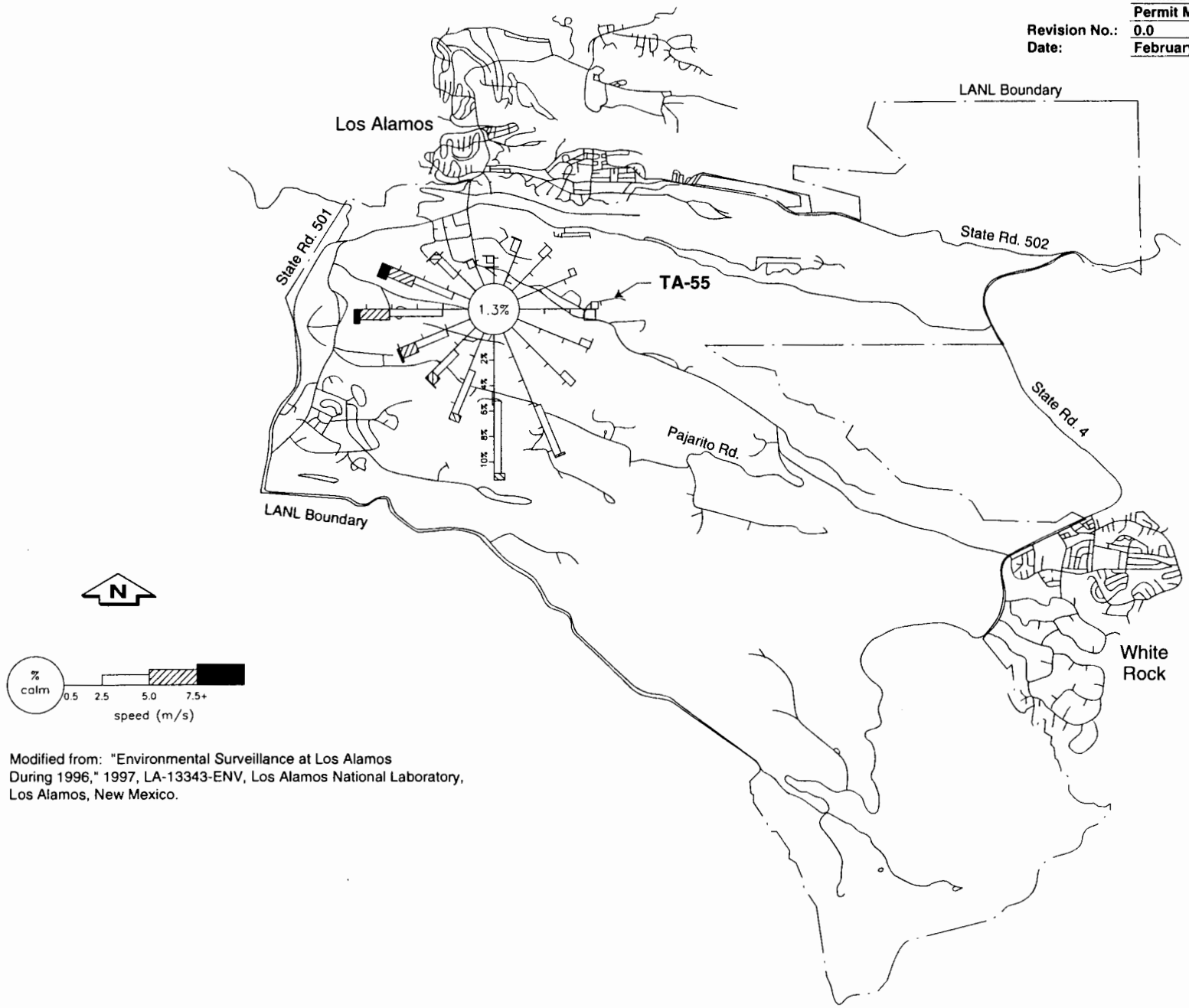


Figure 2-4

Location Map of Access Roads and Traffic Control Signs in the Vicinity of Technical Area (TA) 55

801448 TA-55 Vit

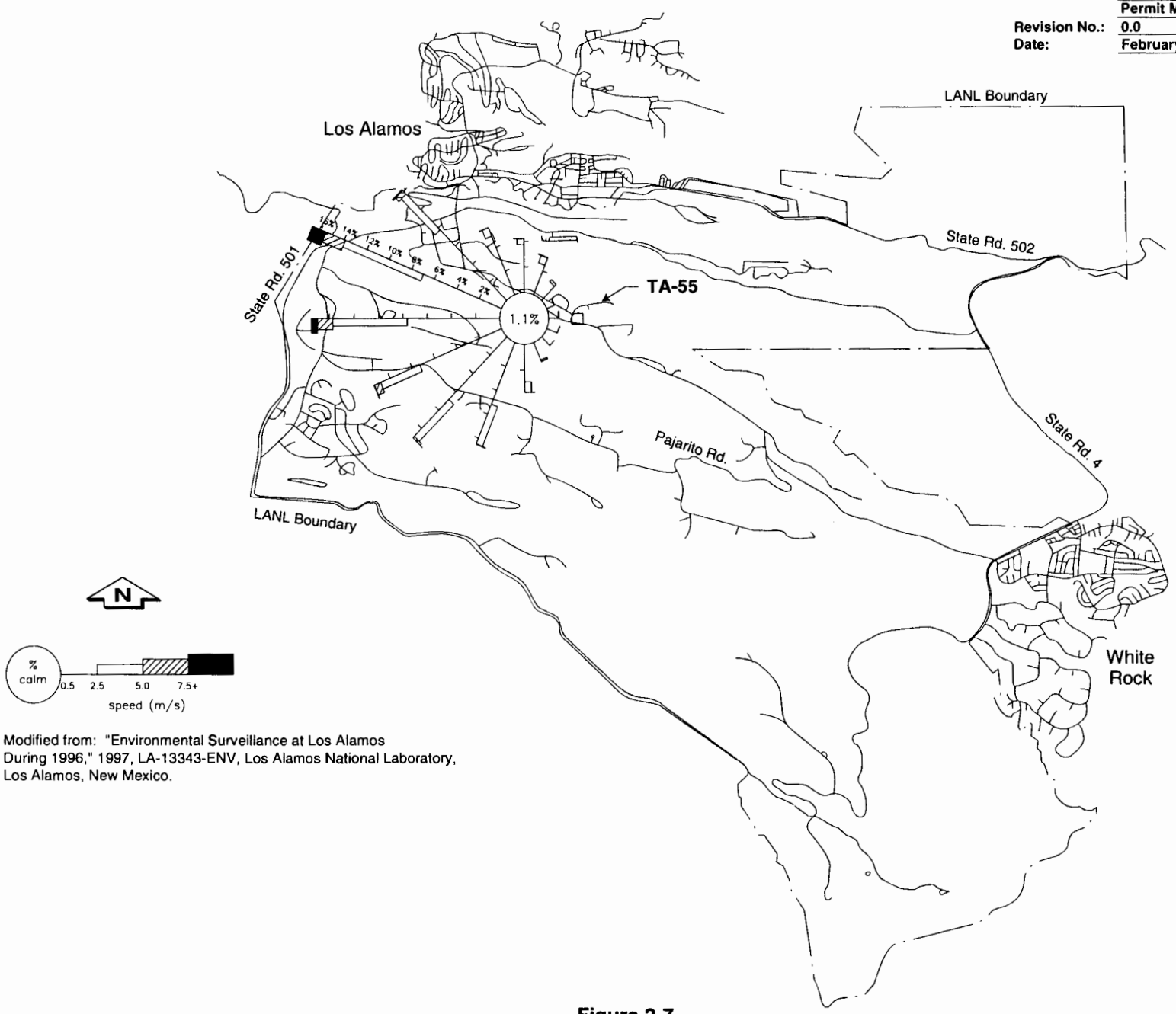


Modified from: "Environmental Surveillance at Los Alamos During 1996," 1997, LA-13343-ENV, Los Alamos National Laboratory, Los Alamos, New Mexico.

Figure 2-6

Annual Wind Roses for Technical Area (TA) 6 at Los Alamos National Laboratory (LANL)—Day

801448 TA-55 Vit



Modified from: "Environmental Surveillance at Los Alamos During 1996," 1997, LA-13343-ENV, Los Alamos National Laboratory, Los Alamos, New Mexico.

Figure 2-7

Annual Wind Roses for Technical Area (TA) 6 at Los Alamos National Laboratory (LANL)—Night

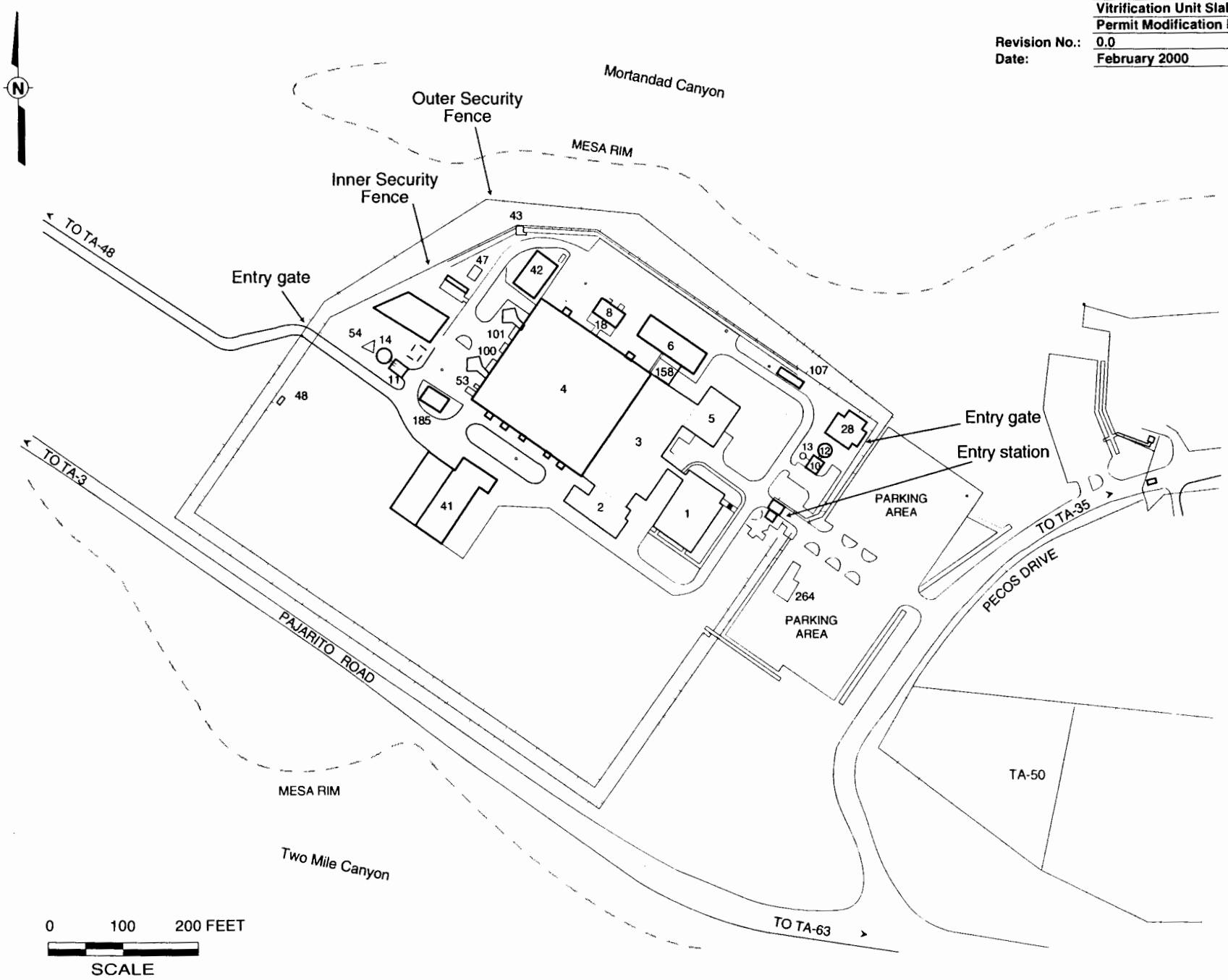
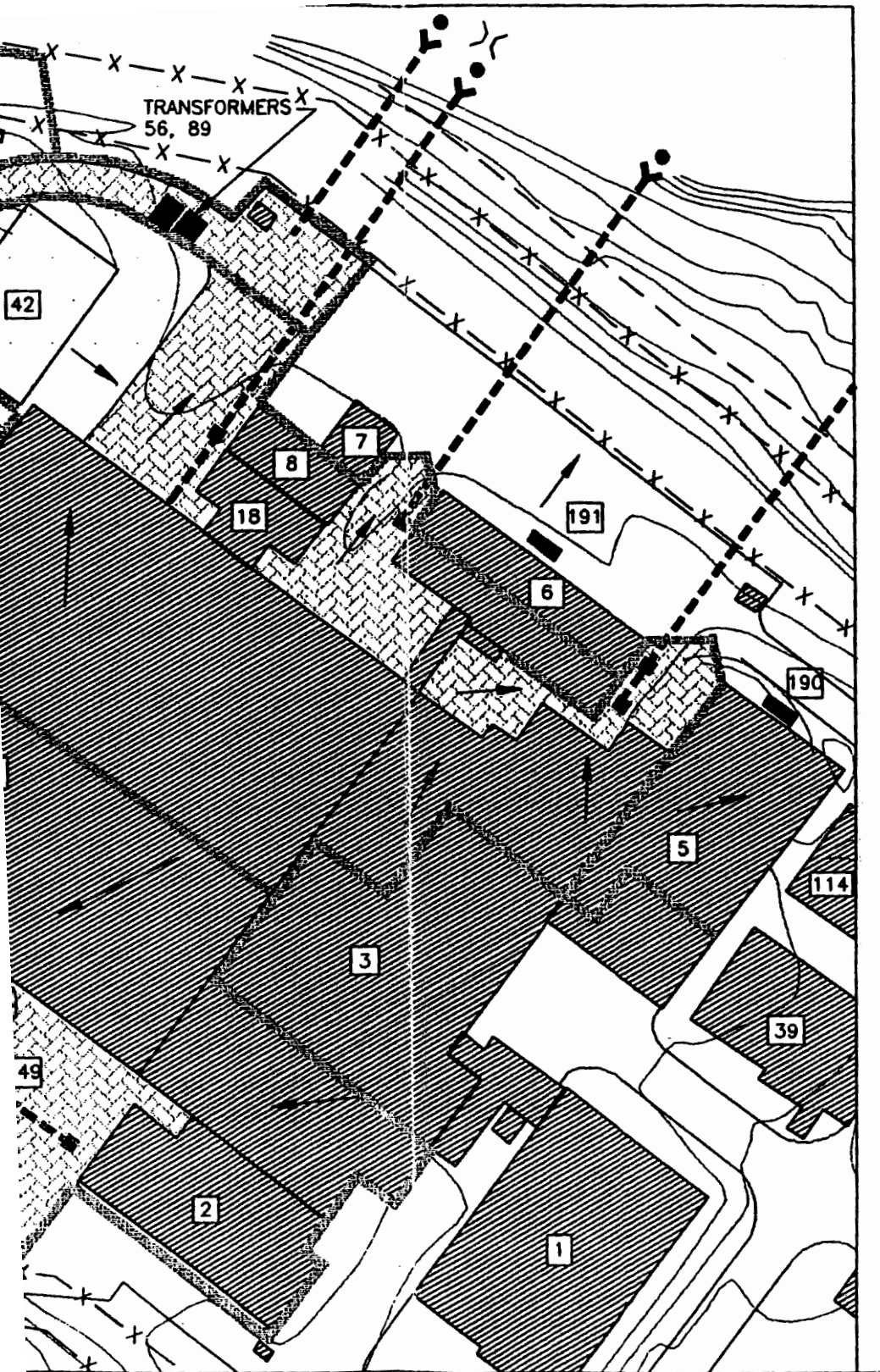


Figure 2-8
Location Map Showing Security Fences, Entry Gates, and Entry Station at Technical Area (TA) 55



NOTE:

1. CONTOURS 10-FT INTERVALS

SYMBOLS LEGEND

	DIRECTION OF STORM WATER FLOW
	DIRT ROAD
	PAVED ROAD
	EXISTING BUILDING
	DRAINAGE BOUNDARY
	CULVERT
	FENCE
	CENTER LINE OF DRAINAGE
	ASPHALT COVERED
	GSIP LOCATION
	AREA OF CONCERN
	SUMP
	STORM WATER DISCHARGE POINT

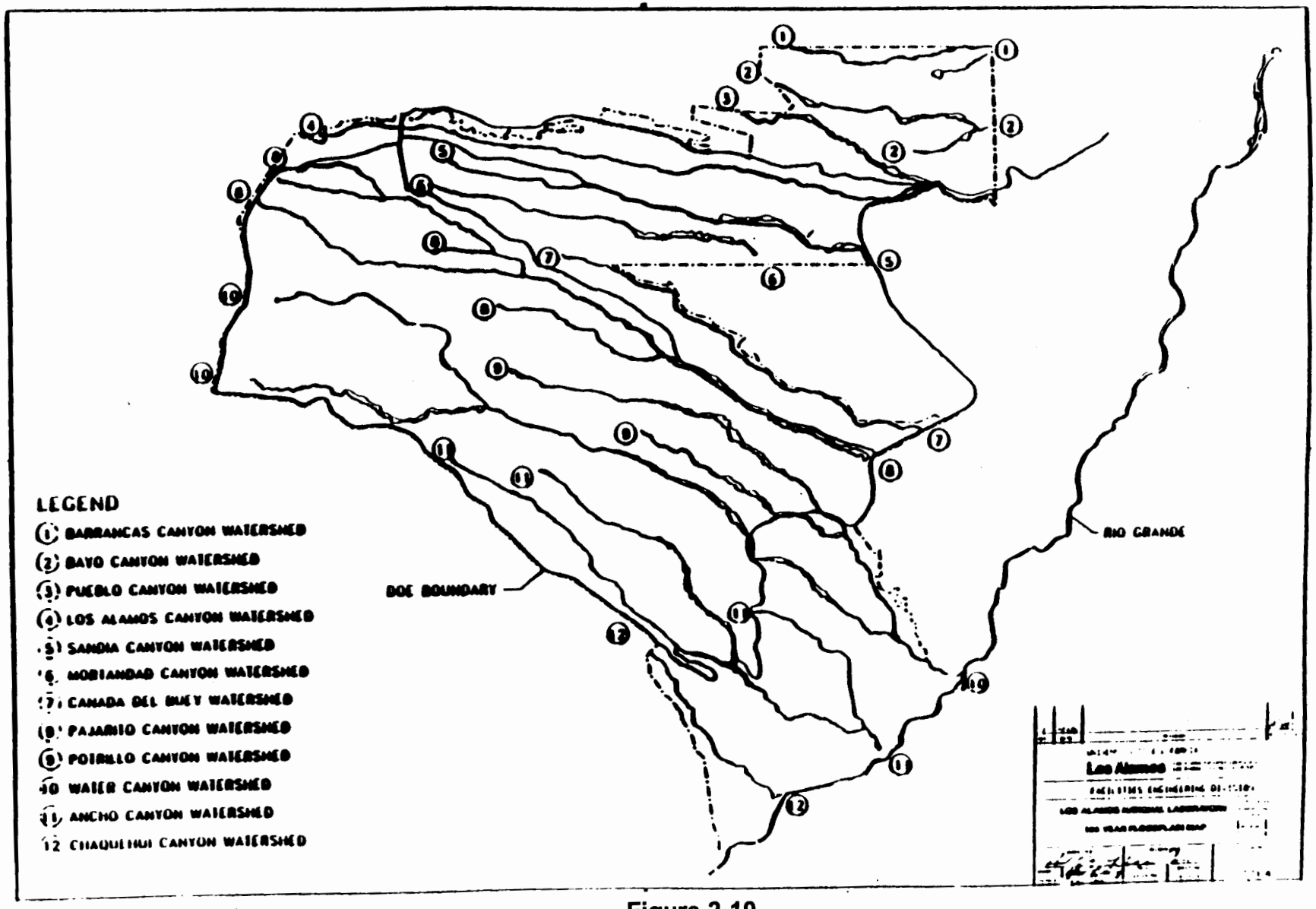


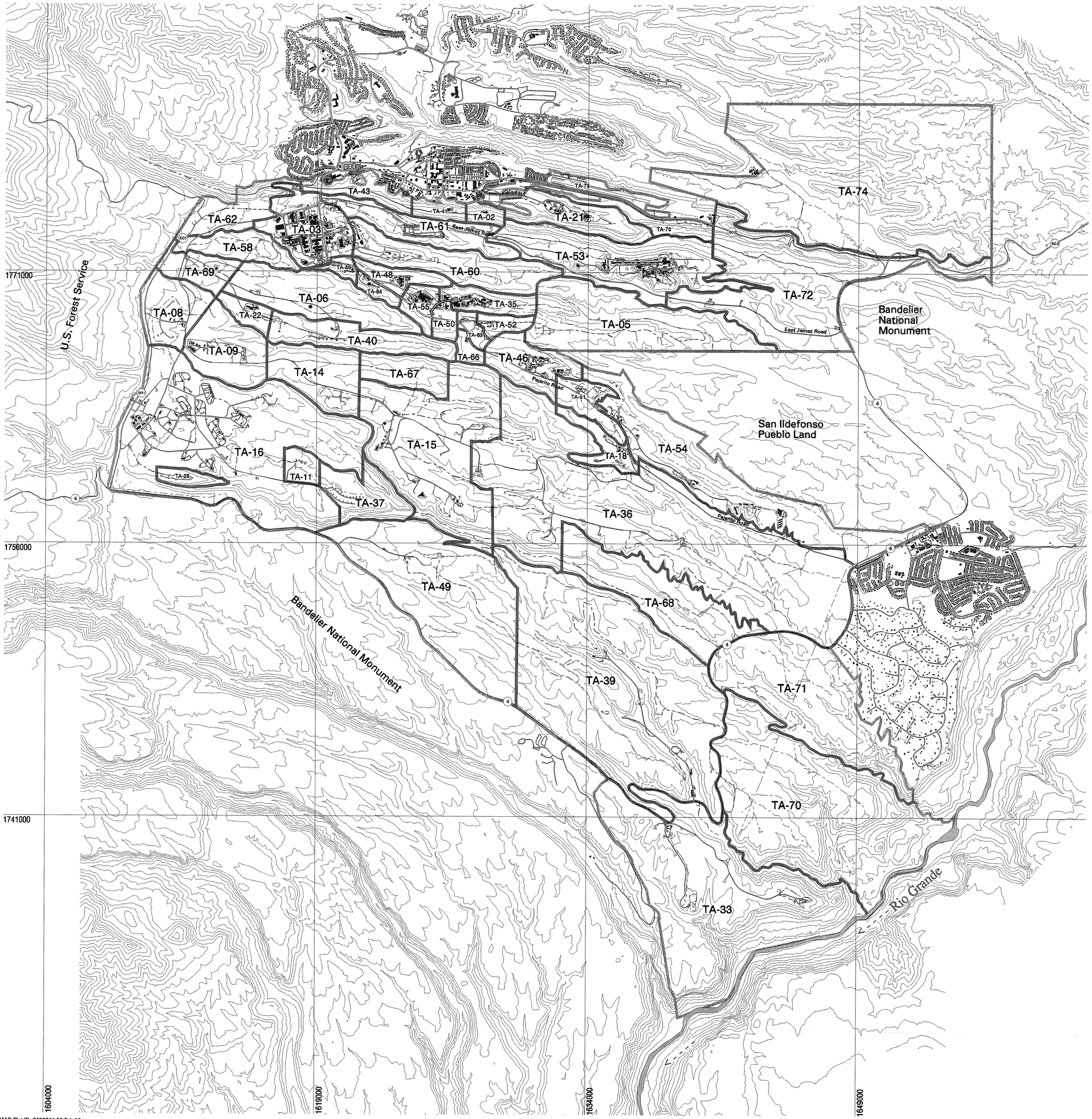
Figure 2-10
LANL 100-Year Floodplain Map

Figure 2-11: Contour Map Showing All Technical Areas (TA) at Los Alamos National Laboratory (LANL)

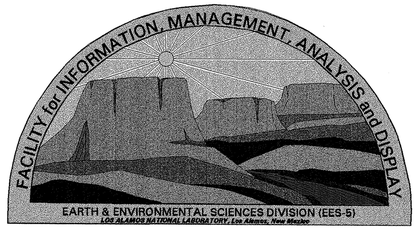
- Boundary, LANL
- Boundary, TA
- Contours, 100 foot
- Roads, Dirt
- Roads, Paved
- Trail
- Building

NOTE: TA-57, Fenton Hill Site, not shown

4450-B



FIMAD Plot ID: G108301 23 Feb 00



Produced by: Marcia Jones
Date: February 23, 2000 FIMAD Plot ID: G108301

N

State Plane Coordinate System, New Mexico Central Zone.
1983 North American Datum

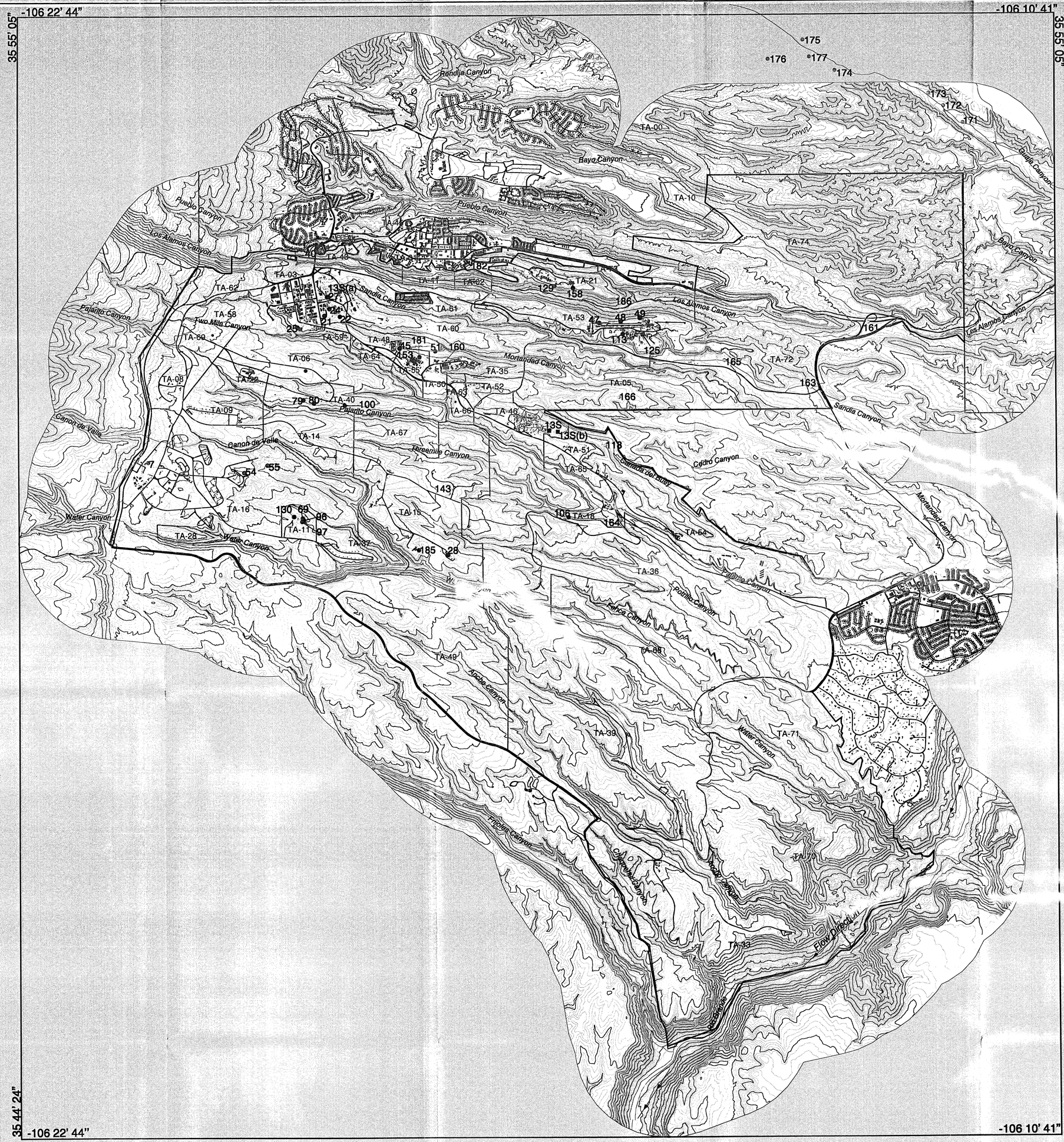
Grid provides NM State Plane coordinates in feet.
Grid interval, in feet: 15000
Feet per inch on map = 3000

SCALE 1:36000

0 914 1828 2742 3656
METERS
0 3000 6000 9000 12000
FEET

Notice: The information on this map is provisional and the accuracy has not been confirmed. Feature locations are dependent on scale and symbology and should not be relied upon to establish legal claims. Basemap Sources: Boundary, structure, and utility data are from Los Alamos National Laboratory Engineering Division and Los Alamos County Utility and Engineering Departments. Contour data is from Los Alamos National Laboratory Environmental Restoration Program aerial survey, September 1991.

MAP 2
Los Alamos National Laboratory (LANL) National Pollutant Discharge Elimination System (NPDES) Outfall Locations



LEGEND

NPDES Outfalls
- 01A
- 02A
- 03A
- 04A
- 05A
- 06A
- 051
- 13S Chlorine Contact Chamber
- 13S(a) Sandia
- 13S(b) Canada del Buey

Contours, 20 ft
Contours, 100 ft
Drainages
Technical Area Boundaries
Buildings
Roads
LANL
1 Mile Boundary

N
W E
S

1:24000

3000 0 3000 6000 9000 Feet

0.7 0 0.7 1.4 2.1 Kilometers

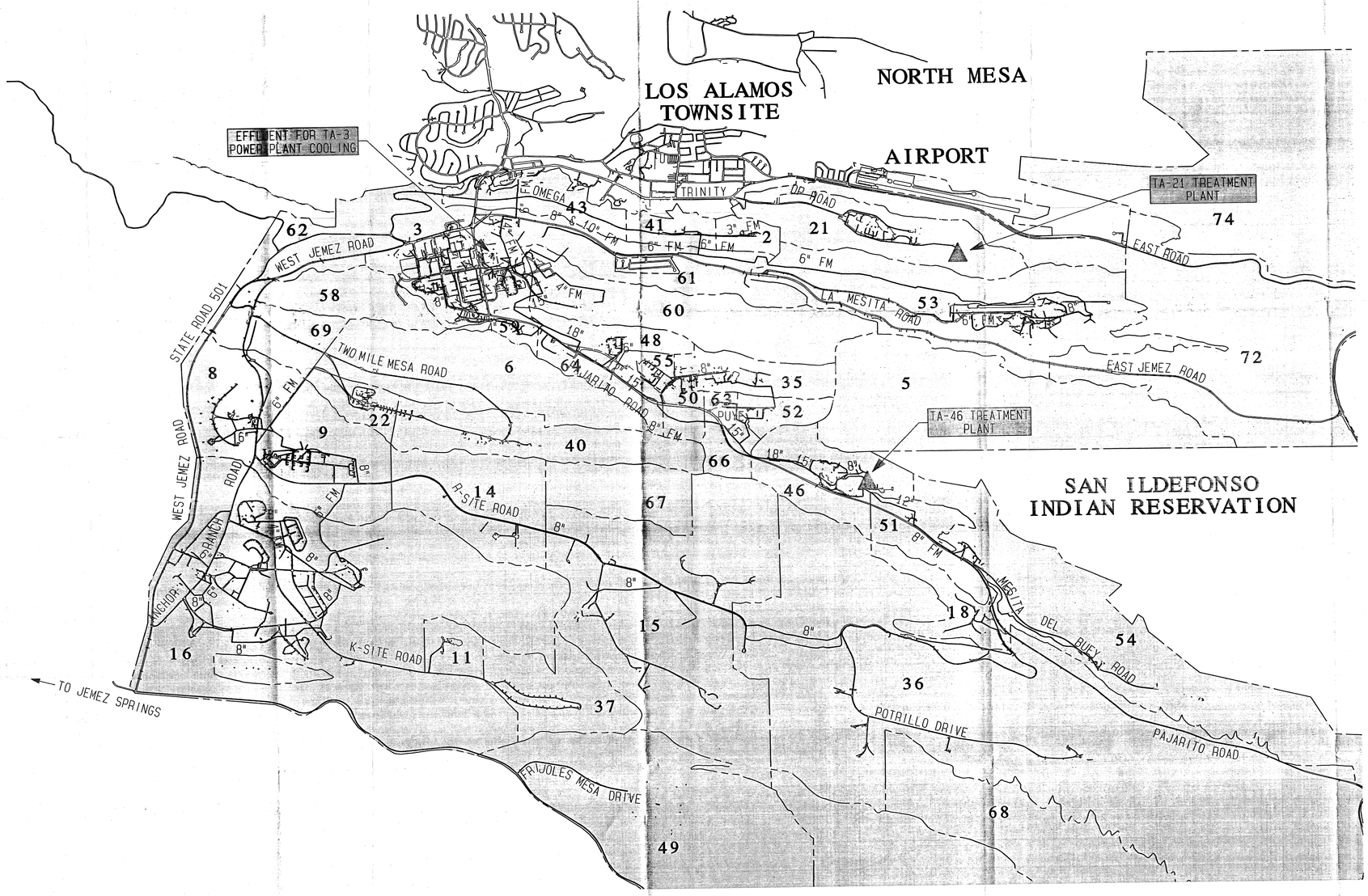
Mapped from State Plane Coordinates, New Mexico Central Zone. 1983 North American Datum. Longitude and latitude are shown at the corners of the map extent.

Los Alamos National Laboratory
Ecology Group
Biology Team

4450-C

Prepared by : Kathryn Bennett
Date: April 10, 1998
Facilities data managed by FIMAD.
Outfall data managed by Ecology Group.

LOS ALAMOS NATIONAL LABORATORY
SANITARY SEWER AND STORM DRAIN SYSTEMS



54 MILES OF SANITARY SEWER LINES

2 TREATMENT PLANTS

48 SEPTIC TANKS

22 MILES OF STORM DRAIN LINES

Map Prepared by:

Johnson Controls
Northern New Mexico

UTILITY MAPPING SECTION

Combining advanced technology and well trained personnel to bring you high quality services for all your Mapping needs.

Note: The data shown on this map has not been checked for accuracy. Map should not be relied upon to establish legal claims or boundary lines.

Basemap Data Sources: Plan data shown is from the Los Alamos National Laboratory Engineering Division 1986 aerial survey, As-Built survey and field measurement updates. Utility data shown is from TGS Technology Computer Mapping Division.

LEGEND

- SANITARY SEWER SYSTEM
- TREATMENT PLANTS
- STORM DRAIN SYSTEM
- DOE PROPERTY

N

SCALE: 1:18000
1500 0 1500 3000 6000
FEET

4450-D

Revised by: RAG

State Plane Coordinate System, New Mexico Central Zone.
1927 North American Datum

Date: June 11, 1998 Phone: (505)665-0559

Figure 2-13
Storm, Sanitary, and Process Sewer Systems at Los Alamos National Laboratory

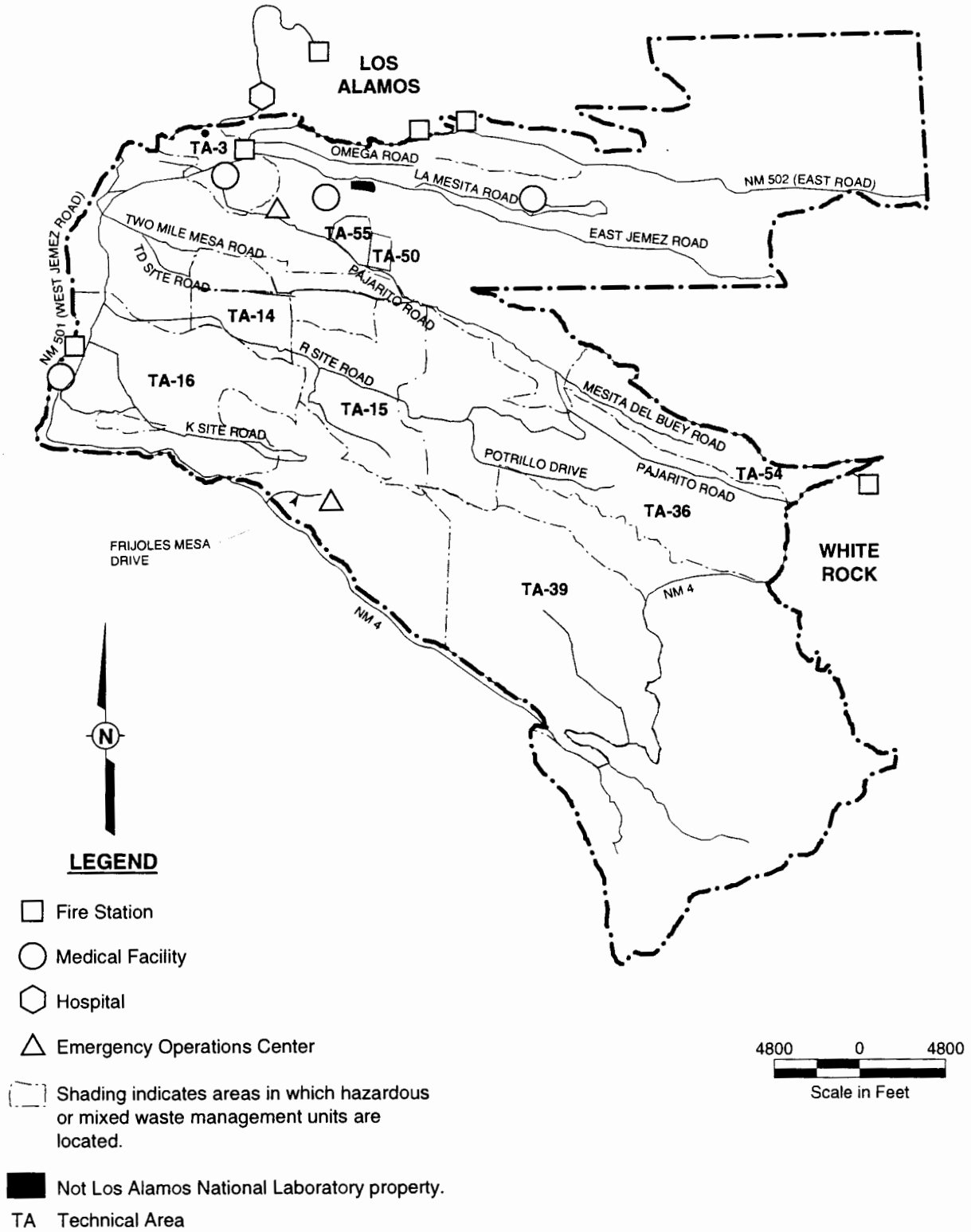


Figure 2-14
Emergency Facilities

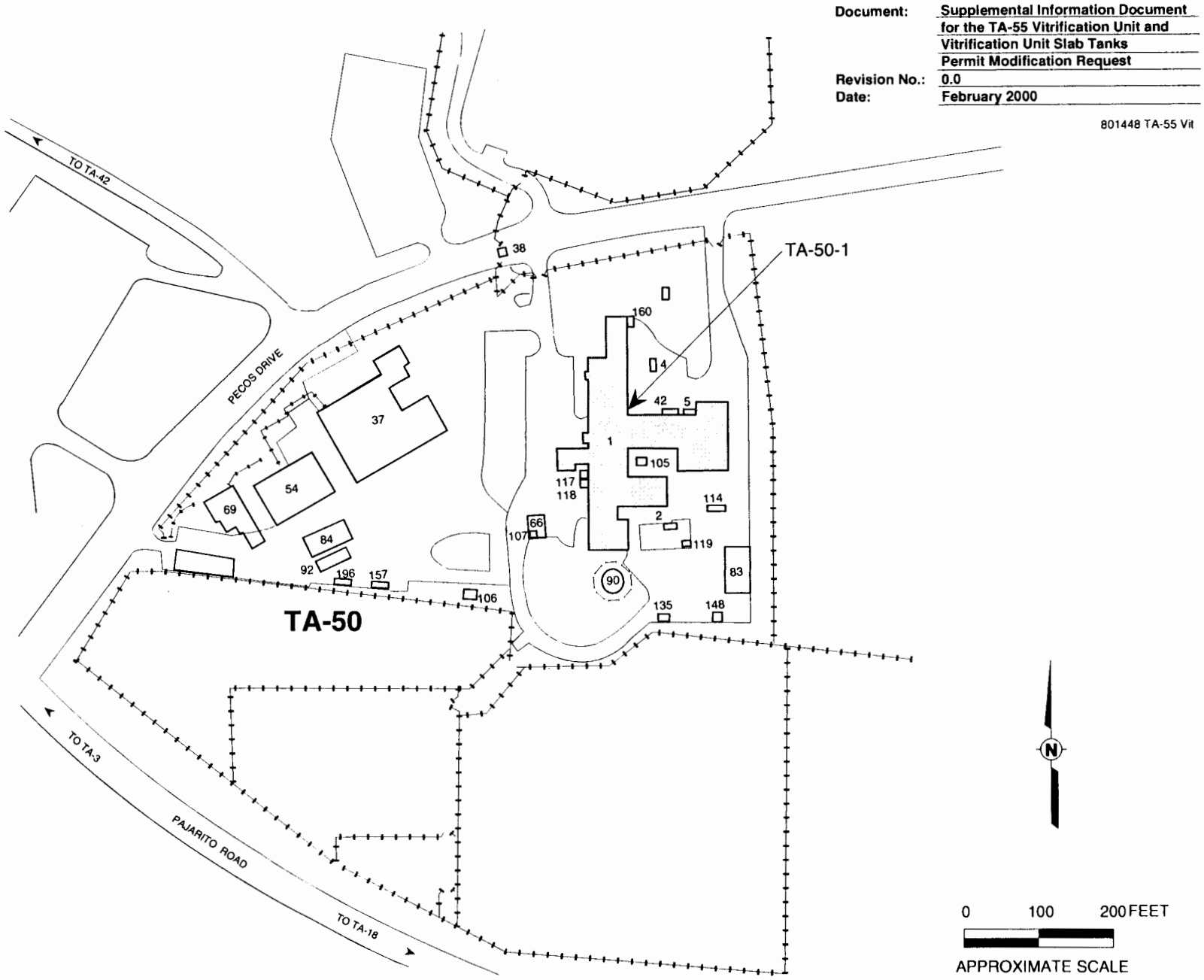


Figure 2-15

Location Map for Los Alamos National Laboratory Equipment Cleanup Area

3.0 GENERAL FACILITY OPERATIONS AND WASTE MANAGEMENT PRACTICES

This section provides an overview of facility operations and waste management practices for the vitrification unit and vitrification unit slab tanks to be installed at Los Alamos National Laboratory (LANL) Technical Area (TA) 55.

3.1 SECURITY AND ACCESS [20 NMAC 4.1, Subpart IX, 270.14(b)(4) and 270.14(b)(19)(viii); 20 NMAC 4.1, Subpart V, 264.14]

Security at TA-55 is maintained with both manmade and natural barriers. These barriers prevent the unknowing entry, and minimize the possibility for unauthorized entry, of persons or livestock into TA-55 and thus satisfy the requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, 264.14, revised January 1, 1997 [1-1-97]. Two 12-foot (ft) high chain-link security fences topped with razor wire surround the entire perimeter of TA-55, as shown on Figure 2-8.

Three entry gates allow access to TA-55. One entry gate is located at the main entrance to TA-55 at the southeast end of the facility; one entry gate is located on the road to TA-48 at the northwest end of TA-55; and one entry gate is located at the northeast corner of TA-55 (for access to TA-55, Building 28 [TA-55-28] only). An entry station is located adjacent to the entry gate at the main entrance to the facility. The entry station is manned 24 hours a day by Protection Technology Los Alamos (PTLA) security personnel. Unescorted access to TA-55 is granted only to persons possessing the appropriate security clearance and meeting specific training requirements.

TA-55 is patrolled by PTLA security personnel during both operational and nonoperational hours to ensure that the gates are locked and that unauthorized entry has not occurred. The entire length of both security fences is also inspected several times each day by on-site security personnel. In accordance with 20 NMAC 4.1, Subpart IX, 270.14(b)(19)(viii) [1-1-97], the locations of the security fences, entry gates, and entry stations are shown on Figure 2-8. In addition to the fence and entry gates, cliffs and canyons surrounding TA-55 provide natural barriers to discourage unauthorized entry.

Warning signs will be posted at each access to the vitrification unit in sufficient numbers to be seen from any approach. The legends on the signs will be bilingual (i.e., English and Spanish) and indicate "Danger, Unauthorized Personnel Keep Out."

3.2 PREPAREDNESS AND PREVENTION [20 NMAC 4.1, Subpart V, Part 264, Subpart C]

The following sections present how operations at TA-55 comply with the preparedness and prevention requirements of 20 NMAC 4.1, Subpart V, Part 264, Subpart C [1-1-97]. A list of the emergency equipment available for use at the vitrification unit and vitrification unit slab tanks is included in Attachment D of the permit modification request. A videotape explaining the alarms and evacuation procedures at TA-55 must be viewed by new visitors prior to entering TA-55.

3.2.1 Required Equipment [20 NMAC 4.1, Subpart V, 264.32]

Buildings at TA-55 are equipped with multiple audible and visual safety-alarm systems to alert personnel in the event of an emergency and to evacuate the area. These alarm systems are located both inside and outside buildings at TA-55 and are monitored and controlled by the facility monitor/control system (FMCS). The FMCS is in operation 24 hours a day and is located in the Operations Center at TA-55-4, with access through TA-55-3. Specific FMCS alarm systems at TA-55 are discussed below.

A TA-55 computer system monitors the smoke and heat sensors, fire-alarm pull boxes, and drop box push-button alarms located throughout TA-55. Fire-alarm pull boxes and/or drop box push-button alarms are located in the vicinity of the vitrification unit and vitrification unit slab tanks. Fire-alarm pull boxes may be used by personnel to activate a local fire alarm when a fire or other emergency is discovered. Fire-alarm pull boxes are located at TA-55-4-401 on the first floor in the vicinity of the vitrification unit and vitrification unit slab tanks. Once manually activated, an alarm (steady high-pitched sound) sounds in the Operations Center and at the Los Alamos County Fire Department (LACFD).

Buildings at TA-55 are equipped with fire-suppression alarm systems and/or smoke detectors. The fire-suppression alarms are activated when water flow is detected in the sprinkler pipes of the fire-suppression system. The smoke detectors, once activated, also sound an alarm. Both types of alarms are area-specific and sound only in the affected area. Red lights are mounted both inside and outside of rooms and at strategic locations throughout TA-55. Upon activation of the fire-alarm system, the alarm sounds and the red lights flash to alert personnel of emergency conditions. All fire-alarm pull boxes, heat and smoke detection systems, and automatic fire-suppression systems at TA-55 are connected to the LACFD through LANL's Central Alarm Station (CAS).

A general evacuation alarm (loud mid-range pulsating tone) is activated by gamma sensors on the ceilings of rooms on the first floor of TA-55-4 in the vicinity of TA-55-4-434A. This evacuation alarm sounds throughout TA-55 and serves to alert personnel to evacuate. It may also be activated by the Operations Center for other emergencies requiring evacuation.

Continuous air monitors (CAM) are located at various locations throughout TA-55-4, Room 401. CAMs will be used as additional leak detection for the vitrification unit and vitrification unit slab tanks by detecting any airborne alpha contamination that would be present if a leak were to occur.

Additionally, TA-55-4 is equipped with a ventilation alarm system designed to monitor air pressure and to monitor ambient air for personnel working in areas where mixed waste is managed. The ventilation system creates zones within TA-55-4 that are at a lower pressure than the outside air. Air flows from the zones of highest pressure to the zones of lowest pressure (highest potential contamination areas). The air flow through the different zones is carefully balanced and controlled to provide the greatest protection to personnel as well as to the environment. If negative air pressure exceeds designated limits, a ventilation alarm (a slow, repeating chime sound) is activated.

In addition to the alarms described above, the public address (PA) system may also be used to announce an evacuation at TA-55. The PA system can be heard throughout TA-55 and is activated by the Operations Center.

TA-55 is equipped with both local paging and conventional telephones to provide adequate communication and to summon external emergency assistance, if necessary. Local paging telephones and speakers and/or conventional telephones will be located near the vitrification unit and vitrification unit slab tanks. Local paging telephones are used to page on-site personnel within the local paging area and may be used in the event of an emergency to communicate the location and nature of hazardous conditions to personnel in the area. The general-evacuation alarm system at TA-55 is interrupted when the TA-55 PA system is activated through the Operations Center. Personnel working at the vitrification unit and vitrification unit slab tanks could also use conventional telephones to call the Operations Center to summon emergency assistance from the TA-55 Emergency Response Team, local police and fire departments, and state emergency response teams, if necessary.

Fire control equipment will be readily available for the vitrification unit and vitrification unit slab tanks. Depending on the size of the fire and the fuel source, portable fire extinguishers may be used by on-site personnel. However, LANL policy encourages immediate evacuation of the area and notification of appropriate emergency personnel. All buildings at TA-55 are equipped with heat and smoke detection systems and/or automatic heat-activated fire-suppression systems to aid in the timely response in the event of fires in these buildings.

Fire hydrants are located on the north, south, and west sides of TA-55-4. Water is supplied to the fire hydrants by a municipal water system, which provides adequate volume and pressure (i.e., greater than 1,000 gallons per minute and 90 pounds per square inch static pressure) to multiple water hoses in the event of a fire. The LACFD will supply all water hoses needed in the event of a fire at TA-55.

Spill control equipment maintained at TA-55 includes a portable spill cart, extra sorbents, and spill pillows. The spill cart can be transported to any location at TA-55-4. The contents of the spill cart may include, but are not limited to: protective suits; polyethylene booties; latex, polyethylene, and neoprene gloves; chemical protective goggles; gas mask canisters; masking, vinyl, and caution tape; spill pillows; neutral acid and neutral base with spray triggers; base neutralizer; tools; cheesecloth; and vinyl bags. Personnel who have the knowledge and training may use this equipment to mitigate small, containable spills when they are certain their actions will not put themselves or others at risk.

Personnel decontamination equipment will be available for personnel working at the vitrification unit and vitrification unit slab tanks. The equipment will include portable eyewash stations and safety showers. Eyewash stations and safety showers will be located in Room 401 within 100 ft of the vitrification unit and vitrification unit slab tanks. A mobile decontamination cart is available and can be transported throughout TA-55. The contents of the decontamination cart may include, but are not limited to, paper hoods and coveralls, protective booties, gloves, tape, radiation tape, mops, buckets, plastic sheeting, soap, liquid cleaner, markers, miscellaneous tools, towels, nose swabs, extension cords, bags, and cheesecloth. Additional mobile decontamination equipment may be provided by LANL's Hazardous Materials Response Group personnel. Material Safety Data Sheets provide useful exposure information and are available in Room 401.

3.2.2 Testing and Maintenance of Equipment [20 NMAC 4.1, Subpart V, 264.33]

All TA-55 communications and alarm systems and fire protection, spill control, and decontamination equipment are tested and/or maintained. The frequency of inspection is adequate to ensure proper operation in the event of an emergency. Repair and replacement of emergency equipment are performed as required.

3.2.3 Access to Communications or Alarm System [20 NMAC 4.1, Subpart V, 264.34]

Whenever mixed waste is being handled in the vitrification unit or vitrification unit slab tanks, all personnel involved will have immediate access to an internal alarm or emergency communication device, either directly or through visual or voice contact with another individual. In the event of an emergency, communication equipment at TA-55 allows personnel to contact the TA-55 Operations Center, the operating group management, the Emergency Response Team, and/or the CAS operator. In addition to communications and alarm systems, TA-55 personnel may carry pagers so that they can be contacted by TA-55 and other LANL emergency support personnel at all times.

3.2.4 Space Requirements [20 NMAC 4.1, Subpart V, 264.35]

Adequate space will be maintained to allow for the unobstructed movement of personnel and fire protection, spill control, and decontamination equipment to any part of the vitrification unit or vitrification unit slab tanks in the event of an emergency.

3.2.5 Support Agreements with Outside Agencies [20 NMAC 4.1, Subpart V, 264.37(a)]

LANL maintains support agreements and contracts with outside agencies for emergency response assistance.

3.3 HAZARDS PREVENTION [20 NMAC 4.1, Subpart V, Part 264, Subpart C; 20 NMAC 4.1, Subpart IX, 270.14(b)(8)]

A description of the preventive procedures, structures, and equipment at TA-55 is presented below. This information is provided in accordance with the requirements of 20 NMAC 4.1, Subpart V, Part 264, Subpart C, and 20 NMAC 4.1, Subpart IX, 270.14(b)(8) [1-1-97]. Adherence to the procedures and proper use of the structures and equipment will help to prevent hazards, undue exposure of personnel to mixed waste, and releases to the environment.

3.3.1 Preventing Hazards in Unloading [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(i)]

Flatbed trucks and trailers or forklifts may be used to transport waste containers to and from the vitrification unit at TA-55. Forklift operators may use a boom, if necessary, to improve handling capabilities. The use of proper handling equipment, appropriate to a container's size and weight, helps to prevent hazards while moving containers. These waste management practices facilitate safe handling of containers.

3.3.2 Preventing Runoff [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(ii)]

Runoff from the vitrification unit or vitrification unit slab tanks to other areas of the facility or to the environment will be prevented. Secondary containment is provided for the vitrification unit and vitrification unit slab tanks by Room 434A. The secondary containment provided by Room 434A will be sufficient to contain 100 percent of the volume of the largest potential liquid-bearing container, pursuant to the requirements of 20 NMAC 4.1, Subpart V, 264.175(b)(3) [1-1-97]. The vitrification unit and vitrification unit slab tanks will have adequate secondary containment as required in 20 NMAC 4.1, Subpart V, 264.193 [1-1-97]. Runoff control of liquids resulting from fire-suppression activities and from leaks or spills will be accomplished by using a vacuum truck, a portable pump, a high-efficiency particulate air (HEPA) vacuum, and/or sorbents, depending on the volume of accumulated liquid. Accumulated liquids will be removed as soon as possible.

3.3.3 Preventing Water Supply Contamination [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(iii)]

It is not anticipated that there will be any impact to groundwater or other water supplies as a result of waste-handling operations at the vitrification unit and vitrification unit slab tanks. The depth to groundwater at TA-55 is approximately 1,200 ft (LANL, 1998a). Permeability rates for soils at TA-55 range from 1.5 to 5.0 centimeter per hour (cm/hr) in the top layers to 0.15 to 5.0 cm/hr in the lower layers. Available water-holding capacity ranges from 0.14 to 0.21 percent (Nyhan et al., 1978). Collectively, the depth to the regional aquifer and the annual moisture deficit significantly limit the potential for contaminants to migrate to the groundwater in the unlikely event that contaminants reach the ground surface surrounding TA-55-4. In addition, all water supply lines are under pressure and are equipped with backflow prevention devices. Pursuant to the requirements of 20 NMAC 4.1, Subpart IX, 270.14(b)(8)(iii) [1-1-97], no impact to water supplies is expected.

3.3.4 Mitigating Effects of Power Outages [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(iv)]

Electrical power will be supplied to operate ventilation systems, the PA system, various instruments, and other electrical equipment at TA-55-4. In the event of a power failure, portable generators are

available from the Nuclear Materials Technology Facilities Management Group support office and at TA-55-3. These generators may be used as temporary power sources. Evacuation alarms located throughout TA-55 are equipped with a battery back-up and will continue to operate for eight hours during a power failure. Operations at the vitrification unit and vitrification unit slab tanks would be discontinued temporarily if electrical power was not restored quickly or if container-handling equipment failed. Neither a power nor an equipment failure would affect containment at the vitrification unit or the vitrification unit slab tanks.

3.3.5 Preventing Undue Exposure [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(v)]

To prevent undue exposure of personnel to mixed waste, personal protective equipment appropriate for the waste being handled will be worn by all on-site personnel at TA-55 involved in waste management activities at the vitrification unit and vitrification unit slab tanks. Workers involved in waste handling are required to wear protective work uniforms and steel-toed shoes, as appropriate. Hard hats and gloves may also be wom while equipment is being operated and when containers are being loaded or unloaded.

3.3.6 Preventing Releases to the Atmosphere [20 NMAC 4.1, Subpart IX, 270.14(b)(8)(vi)]

Releases to the atmosphere are not anticipated from the vitrification unit or vitrification unit slab tanks. The vitrification unit, to be located in TA-55-4-434A, will be operated within a vacuum-pressured glovebox equipped with HEPA filters and is equipped with a ventilation system that creates zones of increasingly positive air pressure. The vitrification unit also includes an off-gas system, which will treat gases produced by the vitrification process. The treated gases exiting the off-gas system are air and excess nitrogen and are discharged to the atmosphere. These systems prevent the release of any airborne contaminants from TA-55-4. The ventilation alarm system and CAMs are located in the vicinity of the vitrification unit and vitrification unit slab tanks. In the event of an unexpected release, all personnel working within or near the area would be notified immediately to evacuate.

4.0 VITRIFICATION UNIT

The information provided in this section is submitted to address applicable miscellaneous unit requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, Part 270.23, and 20 NMAC 4.1, Subpart V, Part 264, Subparts B, C, D, G, X, and BB, revised January 1, 1997 [1-1-97], for the vitrification unit. This section provides a description of the vitrification unit that will be used to vitrify or stabilize evaporator bottoms solutions waste generated at Technical Area (TA) 55. It includes detailed descriptions of the vitrification unit and associated ancillary equipment. Detailed drawings are provided as Figures 4-1 through 4-6 and are provided for informational purposes only. These figures are provided under separate cover to comply with Unclassified Controlled Nuclear Information procedures. Table 4-1 summarizes applicable regulatory references and the corresponding location where the requirement is addressed in this document or in the "Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request," hereinafter referred to as the permit modification request.

4.1 DESIGN, CONSTRUCTION, MATERIALS, AND OPERATION [20 NMAC 4.1, Subpart IX, Part 270.23(a)]

The information for the design of the vitrification unit is based upon a completed design report entitled "Final Design Report for the DP Surety Vitrification System" from Idaho National Engineering and Environmental Laboratory (INEEL) (INEEL, 2000) and design drawings dated February 2000. The vitrification unit will be installed at Los Alamos National Laboratory (LANL), TA-55, Building 4 (TA-55-4), Room 434A, inside Room 401 (Figure 1-1). The unit will be located in a glovebox that will be located in the center of Room 434A and will be approximately 8 feet (ft) wide, 8.5 ft long, and 12 ft tall. The vitrification unit will consist of a single-batch in-can melter, glass frit feed system, glass/waste handling system to cool and move the glass-filled cans, an off-gas system, associated support structures, a glovebox, and associated piping (Figure 4-1).

The vitrification unit will be used to treat evaporator bottoms solutions, a mixed transuranic (TRU) waste, by stabilization into a solid glass matrix. Glass frit will be added to a can located inside the melter and heated to invoke melting. The evaporator bottoms solutions waste will be added to the hot frit and mixed convectively to form a glass matrix. After melting, the can of glass will be lowered into a cooling jacket and mechanically moved away from the melter to cool. A new can will then be inserted into the melter and the process repeated.

The vitrification unit design is capable of processing a maximum of 50 liters (L) per hour of liquid waste for a 10-hour shift and a 4-day work week. At this processing rate, the vitrification system can produce approximately 320 kilograms of glass or 1.3 cans of waste per week (INEEL, 2000). The design specification for the waste loading is 200 ± 50 grams per L as oxides in the liquid waste and a 25 to 30 weight-percent oxides in the glass.

Waste analysis and inspection procedures for the vitrification unit are provided in Attachments A and B of the permit modification request, respectively. The closure plan for the vitrification unit is provided in Attachment E.1 of the permit modification request. The following provides a description of the vitrification unit and meets the requirements of 20 NMAC 4.1, Subpart IX, Part 270.23(a) [1-1-97].

4.1.1 Glass Frit Feed System

The glass frit feed system will supply a dry borosilicate glass frit to the melter in order to perform the vitrification process (specific borosilicate glass characteristics are provided in Appendix 1). All contact surfaces for the glass frit feed system are 304 stainless steel, except for the bulk bag in which the glass frit is shipped and stored. The bulk bag will be located outside TA-55-4 and will be supported by a 16-ft tall carbon-steel support frame that contains the bulk bag, a 304 stainless steel hopper, and an auger conveyor. The glass frit will be unloaded from the bulk bag into the hopper and transferred by a 5-horsepower (HP) motor through the 6-inch (in.) outer diameter (O.D.) auger conveyor to a 283-L hopper. From the 283-L hopper, the glass frit will be transferred by a 3-HP motor through a 2.5-in. O.D volumetric screw feeder and pipe through the wall and above the ceiling of Room 434A to a 142-L batch hopper. The 142-L batch hopper will transfer the glass frit with a 2-in. screw auger through a penetration in the glovebox wall to the melter system (INEEL, 2000). The piping and instrumentation diagram for the glass frit feed system is shown as Figure 4-3.

4.1.2 Melter

The melter will consist of an in-can type configuration with a nominal operating temperature of 1,000 degrees Celsius (°C) and a maximum operating temperature of 1,100°C (INEEL, 2000). The melter will be 34 in. in diameter, 50 in. high, and constructed of 316 stainless steel. Three sets of Silicon Carbide® resistance-heating elements, which surround the melter, will be used to achieve the desired operating temperature. A reusable melter lid will be attached to the top of the can. The lid will be constructed at a standard industrial 2 to 1 elliptical head and constructed of Inconel™ steel (INEEL, 2000). Ports in the lid of the melter will accommodate the introduction of liquid waste and

dry glass frit, an off-gas exhaust port, thermowells or thermocouples for continuous measurements of the temperature inside the melter, and a window to allow for visual observations of the inside of the melter. A 2-in. exhaust port will convey the exhaust gases to the facility wet-vacuum system via the off-gas system. A water-cooled shell will surround the entire insulated melter assembly to reduce the heat load transferred to the interior of the glovebox. The melter can will have an approximate interior diameter of 15.5 in., with a 0.25-in. wall thickness (INEEL, 2000). The can height will be approximately 27 in. with a total volume of approximately 83 L. The operational capacity of the melter can will be approximately 80 percent (67 L) of the total volume. The piping and instrumentation diagram for the melter is shown as Figure 4-4.

4.1.3 Glass/Waste Handling System

The glass/waste handling system will consist of two cooling jackets with mechanized lifts, a glovebox crane, and 55-gallon drums. The cooling jackets will contain the can support, melter can, and bottom plate assembly (can support, insulation, and bottom plate) for the melter (INEEL, 2000). Four screw-mechanized can lifts will raise and lower the melter can and bottom plate assembly into and out of the cooling jacket and melter. After the vitrification process is complete, the cooling jacket, bottom plate assembly, can of glass, and lift will be lowered and rolled out from under the melter to a position where the can of glass will be cooled. While the first can is cooling, another cooling jacket with a new melter can may be moved under the melter and lifted into place. When cooled, the can of glass will be hoisted out of the cooling jacket by a glovebox crane and loaded into a standard 55-gallon drum for "bagout." The 55-gallon drum will contain an inner liner of insulation or padding to keep the melter can from moving within the drum and protect the plastic liner. The piping and instrumentation diagram for the inner can moving mechanism system is shown as Figure 4-5.

4.1.4 Off-Gas System

The function of the off-gas system will be to condense contaminants from the off-gas exiting the melter such that the remaining gases (air and excess nitrogen) can be discharged into the atmosphere via the facility wet-vacuum system. The primary components of the off-gas system will include a quencher, caustic scrubber column, scrubber sump tank, scrubber recycle tanks, scrubber intermediate storage tanks, and heat exchanger (INEEL, 2000). A wet-vacuum system will provide the draft to move the off-gas from the melter, through the quencher and scrubber column, and out the top of the scrubber.

Off-gas from the melter will enter the quencher to be cooled before it enters the bottom of the scrubber and flows through the scrubber column. A sodium hydroxide solution will be pumped from the scrubber recycle tank and injected at the top of the scrubber column. The off-gas and sodium hydroxide solution will countercurrently pass through packing material in the column, which will allow for sufficient contact time and surface area to condense contaminants in the off-gas. The sodium hydroxide solution and condensate will exit at the bottom of the scrubber column, be collected in the scrubber sump tank, and be pumped back to the scrubber recycle tanks for recirculation back into the scrubber (INEEL, 2000). At the end of a batch, the scrubber recycle tanks will be pumped into the scrubber intermediate storage tanks for sampling prior to transfer to the Radioactive Liquid Waste Treatment Facility at TA-50 (INEEL, 2000).

The off-gas will exit the top of the scrubber column and pass into the facility wet-vacuum system before venting to the atmosphere (INEEL, 2000). Heat is removed from the system by recirculating the sodium hydroxide solution from the scrubber through a shell and tube heat exchanger. The cooled liquid is then recycled to the quencher and scrubber column. The heat exchanger will maintain the quencher and scrubber inputs at approximately 20°C.

The off-gas system is designed for a maximum process rate of 50 L per hour of liquid waste entering the melter (INEEL, 2000). This feed rate will produce an off-gas flow rate of approximately 35 standard cubic feet per minute. The primary off-gas waste stream will be produced during the calcination phase of the process and will exit the melter at a temperature between 500°C and 700°C (INEEL, 2000).

The scrubber column, scrubber recycle tanks, scrubber sump tank, and scrubber intermediate storage tanks will be constructed with 316 stainless steel clad. The scrubber column will be approximately 6 in. in diameter and contain approximately 5 ft of packing material (INEEL, 2000). The scrubber column will be located on top of the scrubber sump tank, which will have a capacity of approximately 95 L. The total height of the scrubber column and scrubber sump tank will be approximately 11 ft. The scrubber intermediate storage tanks and scrubber recycle tanks each will have a capacity of approximately 700 L (INEEL, 2000). The piping and instrumentation diagram for the off-gas system is shown as Figure 4-6.

4.1.5 Glovebox

The glovebox will serve as the primary containment for the vitrification unit. A small cooling system will be used, if necessary, to maintain the temperature within the glovebox to the required specification (<40°C) (INEEL, 2000). Overhead cranes will be located in the glovebox to facilitate movement of equipment and cooled cans of glass. The glovebox will be constructed of 0.75-in. lead "sandwiched" between two sections of approximately 0.188-in. thick, low-carbon grade, 316 stainless steel (INEEL, 2000). The glovebox will be approximately 8 ft wide, 8.5 ft long and 12 ft tall.

4.2 VITRIFICATION UNIT DEMONSTRATION OF TREATMENT EFFECTIVENESS [20 NMAC 4.1, Subpart IX, 270.23(d)]

The vitrification unit to be installed at TA-55, Building 4, Room 434A is considered a Subpart X miscellaneous unit and, as such, is subject to the miscellaneous unit requirements in 20 NMAC 4.1, Subpart IX, 270.23(d) [1-1-97] for "a report on a demonstration of the effectiveness of the treatment based on laboratory or field data." Appendix 1 provides a technical paper entitled "Glass Development for Treatment of LANL Evaporator Bottoms Waste," Pacific Northwest National Laboratory (PNNL) (PNNL, 1998). This technical paper contains detailed information that demonstrates that the vitrification unit to be installed at TA-55 will effectively treat evaporator bottoms solutions waste based on the treatment objectives described below and the results of field and surrogate demonstrations.

Vitrification is an attractive treatment option for meeting the stabilization and final disposal requirements of many plutonium (Pu)-bearing materials and wastes at U.S. Department of Energy (DOE) sites. According to 20 NMAC 4.1, Subpart VIII, 268.40 [1-1-97], vitrification is identified as the treatment technology for radioactive wastes characterized as hazardous for toxicity characteristic (TC) metals and corrosivity.

The vitrification unit will be used to stabilize evaporator bottoms solutions waste that contains various radioactive constituents and the TC metals arsenic, barium, cadmium, chromium, lead, and silver. In addition to the TC metals listed above, the evaporator bottoms solutions waste will contain mercury. Vitrification is not an effective treatment technology for mercury due to the temperature at which this treatment process operates. Any mercury that enters the vitrification unit will be vaporized, exhaust to the off-gas system, and condense in the scrubber solution. Appropriate waste management options for mercury in the scrubber solution will be implemented by the facility.

The U.S. Environmental Protection Agency (EPA) recognizes vitrification as an effective treatment technology and has produced a handbook of vitrification technologies for treatment of hazardous and radioactive waste (EPA, 1992). The following sections describe field and surrogate demonstrations conducted to show the treatment effectiveness of vitrification for the TA-55 evaporator bottoms solutions waste.

4.2.1 Field Demonstration

DOE mixed waste streams similar to the evaporator bottoms solutions waste stream generated at TA-55 have been successfully vitrified at a full-scale demonstration. Over 16,000 pounds of mixed waste generated from two separate treatment processes and consisting of sludge compositions similar to the waste generated at TA-55 were successfully vitrified at Oak Ridge National Laboratory in 1997. The mixed waste streams contained average cadmium and chromium concentrations of 5 and 82 milligrams per kilogram, respectively. Based on the full-scale demonstration, all hazardous waste constituents were well retained in the glass waste form, as indicated by the Toxicity Characteristic Leaching Procedure (TCLP) results that were below the regulatory limits (Lockheed Martin Energy Systems, 1998).

4.2.2 Surrogate Demonstration

PNNL demonstrated that vitrification is able to convert Pu-containing materials that exhibit the hazardous characteristics of toxicity for metals into durable and accountable waste forms (PNNL,1998). In 1998, PNNL conducted a study to develop a glass frit composition capable of successfully stabilizing waste compositions potentially generated at TA-55. Glass frit compositions were developed using computer models and optimized using relationships based on measured values for viscosity, durability, and TCLP leach resistance obtained during surrogate testing.

Surrogate testing was conducted for varying glass frit compositions using a test solution with constituents comparable to those expected in the evaporator bottoms solutions waste. The surrogate testing was conducted in crucibles utilizing laboratory conditions similar to the expected operating parameters of the vitrification unit. TCLP analysis of the vitrified waste resulting from the crucible tests for the optimized glass frit composition resulted in concentration levels of TC metals (arsenic, barium, cadmium, chromium, lead, and silver) below the Universal Treatment Standard (UTS)-acceptable levels for TCLP leaching (PNNL, 1998). Table 4-2 shows the UTS limits found in 20 NMAC 4.1, Subpart VIII, 268.48(a) [1-1-97], for the above-mentioned TC metals and summarizes the TCLP release data for the surrogate-based optimized glass composition.

Vitrified waste from TA-55 will be disposed of at the Waste Isolation Pilot Plant (WIPP) and will be subject to WIPP waste acceptance criteria (WAC), which prohibits free liquids (DOE, 1996). The final waste form will meet WIPP WAC by consisting of a solid glass monolith which contains no free liquids. WIPP WAC does not currently specify a durability constraint for the final waste form; however, to meet TCLP the waste form must be durable for storage prior to disposal at WIPP. Pilot-scale melter development and full-scale demonstration testing will be performed once the vitrification unit is constructed. The glass frit composition developed during the surrogate crucible-size tests will be reanalyzed to assure the WIPP WAC and the UTS acceptable levels for TCLP leaching are met. Additional testing will be performed to determine acceptable ranges for key melter parameters, waste blend ratios, waste feed rates, and frit feed rates prior to actual demonstration of the vitrification unit with evaporator bottoms solutions waste generated at TA-55.

4.3 ENVIRONMENTAL PERFORMANCE STANDARDS [20 NMAC 4.1, Subpart IX, 270.23(b) and (c); 20 NMAC 4.1, Subpart V, 264.601]

The following information is provided to address the applicable hydrologic, geologic, and meteorological requirements of 20 NMAC 4.1, Subpart X, 270.23(b) and (c), and 20 NMAC 4.1, Subpart V, 264.601 [1-1-97], for the vitrification unit to be installed at TA-55. The vitrification unit will be installed within a glovebox that will be located in TA-55-4, Room 434A. Room 434A will serve as secondary containment for the vitrification unit. The location of the vitrification unit, the waste management practices outlined in Section 3.0 of this document, and the containment features described in the following sections will prevent the deposition or migration of waste constituents into the groundwater, surface water, soil surface, or the atmosphere and will ensure that the vitrification unit does not violate the environmental performance standards of 20 NMAC 4.1, Subpart V, 264.601 [1-1-97].

Section 4.1 provides detailed information on the design of the vitrification unit. Attachment E.1 of the permit modification request provides closure information.

4.3.1 Protection of the Groundwater/Vadose Zone [20 NMAC 4.1, Subpart V, 264.601(a)]

In accordance with 20 NMAC 4.1, Subpart V, 264.601(a) [1-1-97], the vitrification unit will be operated in a manner that prevents releases that may have adverse effects on human health or the environment due to migration of hazardous constituents through the vadose zone to the groundwater. The vitrification unit will be installed within a glovebox located at TA-55-4, Room 434A, inside Room 401. Room 434A will provide secondary containment for the vitrification unit. The

capacity of the secondary containment is sufficient to contain at least 100 percent of the volume of the largest liquid-bearing container in Room 434A. The entire floor is constructed of 10-in. thick concrete and will be coated with a chemical- and temperature-resistant epoxy primer and epoxy paint. This coating is compatible with the waste treated in the vitrification unit and will effectively prevent the deposition or migration of waste constituents, if spilled, through the concrete and into the groundwater or subsurface environment. Certified operators will inspect the vitrification unit each working day to detect leaks. Additional leak detection will be provided by continuous air monitors (CAM) located at various locations throughout Room 401. CAMs will detect any airborne alpha contamination that would be present if a leak were to occur resulting in a release outside of the glovebox. In the event of a release, the materials in question will be removed as quickly as possible and will be packaged in an appropriate container.

The vitrification unit will be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. The conditions outlined in 20 NMAC 4.1, Subpart V, 264.601(a) [1-1-97], were considered and there is little or no potential for disposition or migration of waste constituents into the groundwater or subsurface environment. The vitrification unit will be located inside a building, provided with secondary containment, designed and constructed as described in Section 4.1, operated and maintained in accordance with waste management procedures described in Section 3.0 of this document, and closed in accordance with the procedures described in Attachment E.1 of the permit modification request; therefore, adverse effects on human health or the environment due to the treatment operations conducted in the vitrification unit are unlikely.

4.3.2 Protection of Surface Water/Wetlands/Soil Surface [20 NMAC 4.1, Subpart V, 264.601(b)]
In accordance with 20 NMAC 4.1, Subpart V, 264.601(b) [1-1-97], the vitrification unit will be operated in a manner that prevents releases that may have adverse effects on human health or the environment due to the deposition or migration of waste constituents into surface water, wetlands, or onto the soil surface. Section 4.3.1 provides a detailed description of the effectiveness and reliability of the containment features to be utilized by the vitrification unit to prevent releases.

The vitrification unit will be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment. The conditions outlined in 20 NMAC 4.1, Subpart V, 264.601(b) [1-1-97], were considered and there is little or no potential for deposition or migration of waste constituents into surface water, wetlands, or soil surface. The

vitrification unit will be located inside a building, provided with secondary containment, designed and constructed as described in Section 4.1, operated and maintained in accordance with waste management procedures described in Section 3.0 of this document, and closed in accordance with the procedures described in Attachment E.1 of the permit modification request.

4.3.3 Protection of the Atmosphere [20 NMAC 4.1, Subpart V, 264.601(c)]

In accordance with 20 NMAC 4.1, Subpart V, 264.601(c) [1-1-97], the vitrification unit will be operated in a manner that prevents releases that may have adverse effects on human health or the environment. The following paragraphs provide information required by 20 NMAC 4.1, Subpart V, 264.601(c) [1-1-97].

The vitrification unit will treat a maximum of 50 L per hour of mixed TRU waste solutions generated at TA-55. These waste solutions will be generated as evaporator bottoms and will consist of concentrated nitric acid saturated with salts and metals. This waste will typically exhibit the hazardous characteristics of toxicity for metals and corrosivity.

The vitrification unit will be operated such that emissions of hazardous constituents to the atmosphere do not occur. It will be located within a negative pressure glovebox equipped with high-efficiency particulate air filters. In addition, the glovebox will be located within three succeedingly greater pressure zones. These zones are (in order of increasing pressure) the glovebox, Room 434A/Room 401, and the main corridor outside of Room 401. These pressure zones are designed to create an air flow into Room 434A and the glovebox and limit the potential for hazardous constituents to migrate to the atmosphere. The vitrification unit will produce off-gas emissions during the vitrification process. These emissions will be treated by an off-gas system, which will condense contaminants such that the remaining gases (air and excess nitrogen) can be discharged to the atmosphere. This off-gas system is described in detail in Section 4.1 of this document.

The complex topography of the Pajarito Plateau, on which TA-55 is located, affects the winds at LANL, particularly in the absence of a large-scale disturbance. Often, a distinct daily cycle of winds can be seen. During the daytime, upslope flow sometimes exists, causing a southeasterly component to the winds. During the nighttime, as the mountain slopes and plateau cool, the flow becomes downslope, causing the light westerly and northwesterly flow (LANL, 1998b). In general, the surface winds in the vicinity of TA-55 are light, averaging 7 miles per hour. The predominant prevailing wind direction is from the southwest to the northeast. Figures 2-6 and 2-7 of this document depict wind roses for TA-6, which is located directly west of TA-55.

Provisions of 20 NMAC 2.3 establish ambient air quality standards, referred to as New Mexico Ambient Air Quality Standards (NMAAQS), to protect the quality of the air in New Mexico and specify maximum allowable ambient concentrations for certain pollutants. Additionally, EPA has established air quality standards, referred to as National Ambient Air Quality Standards (NAAQS), under Title 40 of the Code of Federal Regulations (40 CFR), Part 50. The ambient air quality in and around LANL meets NMAAQS, NAAQS, and DOE standards for protection of workers and the public. An assessment of the ambient impacts of criteria pollutant emissions (e.g., particulate matter, carbon monoxide, oxides of nitrogen, and oxides of sulfur), presented in the "Site-Wide Environmental Impact Statement for Los Alamos" (DOE, 1999), further indicates that no adverse air quality impacts result from combustion and industrial sources at LANL (LANL, 1998b).

Operation of the vitrification unit will not impact air quality at LANL. The vitrification unit will be operated within a negative pressure environment and will be equipped with an off-gas treatment system; therefore, adverse affects on human health or the environment due to migration of hazardous constituents to the atmosphere as a result of the treatment operations conducted in the vitrification unit are unlikely. There is little or no potential for health risks caused by human exposure to waste constituents or for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents.

4.4 SPECIAL REQUIREMENTS FOR IGNITABLE, REACTIVE, OR INCOMPATIBLE WASTES [20 NMAC 4.1, Subpart IX, 270.16(j); 20 NMAC 4.1 Subpart V, 264.17]

There are no plans to treat ignitable, reactive, or incompatible wastes in the vitrification unit.

4.5 AIR EMISSION STANDARDS FOR EQUIPMENT LEAKS [20 NMAC 4.1, Subpart V, 264.1064(k); 40 CFR Part 264, Subpart BB]

The vitrification unit is not subject to 40 CFR, Part 264, Subpart BB [1-1-97], "Air Emission Standards for Equipment Leaks," with the exception of the reporting requirements specified in 20 NMAC 4.1, Subpart V, 264.1064(k) [1-1-97]. None of the equipment associated with the vitrification unit at TA-55 will contain or contact mixed waste with organic concentrations of at least 10 percent by weight.

In accordance with 20 NMAC 4.1, Subpart V, 264.1064(k) [1-1-97], TA-55 will use knowledge of the nature of the evaporator bottoms solutions waste stream or knowledge of the process by which the evaporator bottoms solutions waste stream is produced to document their exemptions to these standards. Production process information documenting that no organic compounds are contained in or contacted by equipment associated with the vitrification unit will be recorded in TA-55's facility operating record.

Table 4-1

Regulatory References and Corresponding Location for the Vitrification Unit

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§264.601	Environmental Performance Standards	4.3
§264.601(a)	Prevention of release of contaminants to groundwater	4.3.1
§264.601(a)(1)	Volume and characteristics of waste considering potential for migration through containment structures	4.3.1
§264.601(a)(2)	Hydrologic/geologic characteristics	4.3.1
§264.601(a)(3)	Quality of groundwater including other sources of contamination and their cumulative impact on groundwater	4.3.1
§264.601(a)(4)	Quantity and direction of groundwater flow	4.3.1
§264.601(a)(5)	Proximity to and withdrawal rates of potential groundwater users	4.3.1
§264.601(a)(6)	Regional patterns of land use	4.3.1
§264.601(a)(7)	Potential for deposition and migration of waste constituents	4.3.1
§264.601(a)(8)	Potential for health risks caused by human exposure to waste constituents	4.3.1
§264.601(a)(9)	Potential for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents	4.3.1
§264.601(b)	Prevention of release of contaminants to surface water or soil surface	4.3.2
§264.601(b)(1)	Volume and characteristics of the waste	4.3.2
§264.601(b)(2)	Effectiveness and reliability of containment, confinement, and collection systems and structures	4.3.2
§264.601(b)(3)	Hydrologic characteristics of the unit and local area, including topography	4.3.2
§264.601(b)(4)	Regional precipitation patterns	4.3.2
§264.601(b)(5)	Quantity, quality, and direction of groundwater flow	4.3.2
§264.601(b)(6)	Proximity of the unit to surface water	4.3.2
§264.601(b)(7)	Current and potential uses of nearby surface waters and any water quality standards for those waters	4.3.2
§264.601(b)(8)	Quality of surface waters and soils including other sources of contamination and their cumulative impact on surface waters and soils	4.3.2
§264.601(b)(9)	Regional patterns of land use	4.3.2
§264.601(b)(10)	Potential for health risks caused by human exposure to waste constituents	4.3.2
§264.601(b)(11)	Potential for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents	4.3.2

See footnotes at end of table.

Table 4-1 (continued)

Regulatory References and Corresponding Location for the Vitrification Unit

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§264.601(c)	Prevention of release of contaminants to air	4.3.3
§264.601(c)(1)	Volume and characteristics of waste including its potential for emission	4.3.3
§264.601(c)(2)	Effectiveness and reliability of systems/structures to reduce/prevent emissions of hazardous constituents to the air	4.3.3
§264.601(c)(3)	Operating characteristics of the unit	4.3.3
§264.601(c)(4)	Characteristics of the unit and the surrounding area	4.3.3
§264.601(c)(5)	Existing quality of the air including other sources of contaminants and their cumulative impact on the air	4.3.3
§264.601(c)(6)	Potential health risks caused by human exposure to waste constituents	4.3.3
§264.601(c)(7)	Potential for damage to domestic animals, wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents	4.3.3
§264.602	Monitoring, analysis, inspection, response, reporting, and corrective action	4.3, Attachment B[a], 3.2, 6.0, 7.0
§264.603	Post-closure care	Attachment E.1[a]
§264.15	General inspection requirements	Attachment B[a]
264.33	Testing and maintenance of equipment	3.2.2
§264.75	Biennial report	6.1
§264.76	Unmanifested waste report	6.2
§264.77	Additional reports	6.3
§264.101	Corrective action for solid waste management units	7.0
§264.118	Post-closure plan; amendment of plan	Attachment E.1[a]

[a] Located in the "Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request."

Table 4-2

Universal Treatment Standards and Surrogate-Based TCLP Release Data for Technical Area 55 Hazardous Waste Metals of Concern

Hazardous Constituent	UTS Concentration Limit[a] (mg/L)	TCLP Release Data[b] (mg/L)
Arsenic	5	0.00113
Barium	21	0.00337
Cadmium	0.11	0.00098
Chromium	0.6	0.55353
Lead	0.75	0.02946
Silver	0.14	0.00013

[a] "Universal Treatment Standards," 20 NMAC 4.1, Subpart VIII, 268.48(a) [1-1-97]
[b] "Glass Development for Treatment of LANL Evaporator Bottoms Waste," *PNNL-11865 UC-510*, Pacific Northwest National Laboratory, Richland, Washington.
UTS = Universal Treatment Standard
mg/L = milligrams per liter
TCLP = Toxicity Characteristic Leaching Procedure

Figures 4-1 through 4-6 have been provided confidentially under separate cover.

5.0 VITRIFICATION UNIT SLAB TANKS

The information provided in this section is submitted to address the applicable tank system requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.16, and 20 NMAC 4.1, Subpart V, Part 264, Subparts B, C, D, G, J, BB, and CC, revised January 1, 1997 [1-1-97], for the two vitrification unit slab tanks to be installed at Los Alamos National Laboratory, Technical Area (TA) 55, Building 4, Room 434A. This section provides a description of the vitrification unit slab tanks that will be used to store evaporator bottoms solutions waste prior to treatment in the vitrification unit. It includes detailed descriptions of the vitrification unit slab tanks and associated ancillary equipment.

The vitrification unit slab tanks are subject to new tank system regulations, in accordance with the requirements of 20 NMAC 4.1, Subpart V, 264.192 [1-1-97]. The Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks, as required by 20 NMAC 4.1, Subpart V, 264.192(a) [1-1-97], is provided as Appendix 2. Detailed drawings and information are presented as Figures 5-1 through 5-5 and are provided for informational purposes only. The figures are provided under separate cover to comply with Unclassified Controlled Nuclear Information procedures. Table 5-1 summarizes applicable regulatory references and the corresponding location where the requirement is addressed in this document or in the "Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request," hereinafter referred to as the permit modification request.

5.1 DESIGN, CONSTRUCTION, MATERIALS, AND OPERATION [20 NMAC 4.1, Subpart IX, 270.16(b), (c), (d) and (i); 20 NMAC 4.1, 264.192(e) and 264.194]

The information for the design of the vitrification unit slab tanks is based upon a completed design report entitled "Final Design Report for the DP Surety Vitrification System" from Idaho National Engineering and Environmental Laboratory (INEEL) (INEEL, 2000) and design drawings dated February 2000. The vitrification unit slab tanks will consist of two slab tanks and associated ancillary equipment located in Room 434A, which is located within Room 401, at TA-55, Building 4 (TA-55-4) (Figure 1-1). The vitrification unit slab tanks will be used to store evaporator bottoms solutions, a mixed transuranic waste, prior to stabilization in the vitrification unit. The vitrification unit slab tanks will be connected to three main piping systems, which include the solution-feed, wet-vacuum, and vent systems. The wet-vacuum piping system will be used for all transfers; and the vent-piping system will be used to break vacuum. The wet-vacuum and vent-piping systems use vacuum traps

to capture carryover liquid and prevent contamination of the lines downstream. One vacuum pump serves the vitrification unit slab tanks for liquid transfers and for vacuum sparging.

The following provides a description of the vitrification unit slab tanks and associated ancillary equipment and meets the requirements of 20 NMAC 4.1, Subpart IX, 270.16(b), (c), (d), and (i), and 20 NMAC 4.1, Subpart V, 264.192(e) and 264.194 [1-1-97].

5.1.1 Vitrification Unit Slab Tanks

The two vitrification unit slab tanks will each have a capacity of approximately 125 liters (L) and will each be approximately 24 inches (in.) long, 4 in. wide, and 82.5 in. high (Figures 5-1 and 5-2). The tanks will be parallel piped and will be constructed of 316L stainless steel plates, seal welded into a vacuum-tight containment structure. Each tank will be reinforced with steel tubes, which will connect to the interior opposite sides of the tank on 6-in. centers to prevent the tank wall from bulging outward. The bottom of each tank will incorporate a 15-degree slope to mitigate plating and facilitate complete drainage. The tanks will be corrosion resistant and compatible with the liquid waste to be stored in them. The slab tanks are designed in accordance with the latest applicable standards and will be installed such that, if necessary, they can be replaced.

The primary containment welds for each slab tank will be vacuum tight in accordance with the American Society of Mechanical Engineers "ASME Boiler and Pressure Vessel Codes, Section VIII" (ASME, 1998) (hereinafter referred to as ASME BPVC Section VIII), Division 1, Subsection B, Part UW-19. All penetrations into the shell of the tanks will be designed and fabricated to ensure vacuum tightness and will comply with ASME BPVC Section VIII, Division 1. However, an ASME stamp will not be required for the vitrification unit slab tanks because they will not be operated as pressurized vessels. The vitrification unit slab tanks will be oriented vertically and an air sparge will be inserted in each tank to agitate the waste. The connections to the tank will be via standard weld neck flanges. Each tank will be vented to the facility-process vent system when waste is being pumped to the vitrification unit. Feed to the tanks will be accomplished with remote control valves and a feed pump. In accordance with 20 NMAC 4.1, Subpart IX, 270.16(i), and 20 NMAC 4.1, Subpart V, 264.194(b) [1-1-97], sight and electronic liquid-level indicators will be mounted on the side of each slab tank for spill and overfill protection.

5.1.2 Piping and Ancillary Equipment

The vitrification unit slab tanks will be connected to system headers (for feed, ventilation, and vacuum) by a manifold that is constructed of seamless, 316L stainless steel and meets the chemical and physical characteristics given in American Society for Testing and Materials (ASTM) "A312–Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes" (ASTM, 1995), hereinafter referred to as ASTM A312 for Grade TP316L. Figures 5-3 and 5-4 provide a legend and a piping and instrumentation diagram for the vitrification unit slab tanks. This piping will match the existing system of 0.75-in., Schedule 40 pipe. It will meet the requirements of ASME "B31.3–Process Piping" (ASME, 1996a) for Normal Fluid Service for a design pressure of 15 pounds per square inch and design temperature of 10 degrees Fahrenheit. All piping connections will be flanged and gasketed and will be provided in accordance with ASME "B16.5–Pipe Flanges and Flanged Fittings" (ASME, 1996b). The flanges will be forged from stainless steel and will meet the requirements of ASTM "A182–Standard Specification for Forged or Rolled Alloy–Steel Pipe Flanges, Forged Fittings and Valves, and Parts for High-Temperature Service" (ASTM, 1997) for Grade F316L. Gaskets will be sized for 0.75-in., Schedule 40, 150# raised face flanges.

The vitrification unit slab tanks will be equipped with a vacuum trap that is designed to collect any mists or carryover liquid that might accumulate in the vacuum or vent lines. The vacuum trap will be constructed of Schedule 40, seamless stainless steel pipe, with an outer diameter of approximately 6.25 in., and that meets the chemical and physical characteristics given in ASTM A312 for Grade TP316L. In accordance with 20 NMAC 4.1, Subpart IX, 270.16(i), and 20 NMAC 4.1, Subpart V, 264.194(b) [1-1-97], the vacuum trap will be equipped with a sight glass for local level indication for spill and overfill protection and will normally be empty. A float device will be located inside the vacuum-trap and will plug the outlet pipe if the liquid reaches a level where it can overflow from the trap.

5.1.3 Foundation and Tank Support

In accordance with 20 NMAC 4.1, Subpart V, 264.192(e) [1-1-97], the vitrification unit slab tanks and associated ancillary equipment will be bolted to the 10-in. thick concrete floor and 14-in. thick south wall of TA-55-4, Room 434A. The floor provides a foundation that will maintain the load of the vitrification unit slab tanks when full. The concrete floor and ceiling were constructed to conform to the building code requirements of the American Concrete Institute (ACI) "318–Building Code Requirements for Structural Concrete and Commentary" (ACI, 1995) for reinforced concrete. The reinforcing steel was detailed and fabricated in accordance with ACI "315–Details and Detailing of

Concrete Reinforcement" (ACI, 1992). The design construction and tolerance of the framework around the concrete is in accordance with ACI "347–Guide to Formwork for Concrete" (ACI, 1994).

Each of the vitrification slab tanks will be mounted to the wall by two 316L stainless steel mounting plates that are approximately 5 in. long, 4 in. wide, 0.5 in. thick and meet the requirements of ASTM "A240–Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels" (ASTM, 1998a). The mounting plates will be welded to a 304 stainless steel beam that is approximately 2.4 in wide, 0.25 in thick and meets the requirements of ASTM "A276-Standard Specification for Stainless Steel Bars and Shapes" (ASTM, 1998b), and the beam will be welded to the tank. The bottom of each tank will be welded to three Schedule 40, 316L stainless steel pipes that will be approximately 2.5 in. in diameter. These pipes will be welded to a single 316L stainless steel mounting plate, approximately 24 in. long, 4.3 in. wide, 0.375 in. thick, that is bolted to the floor (Figures 5-1 and 5-2).

The vitrification unit slab tanks will not operate under pressure; therefore, excessive stress due to expansion and contraction are not anticipated. The vitrification unit slab tanks will not be located within a saturated zone or seismic fault zone and will be inside a building, so frost heave effects are not expected.

5.2 INSTALLATION, TESTING, AND CERTIFICATION [20 NMAC 4.1, Subpart IX, 270.16(a) and (f); 20 NMAC 4.1, Subpart V, 264.192(a),(b), (d), and (g)]

In accordance with 20 NMAC 4.1, Subpart IX, 270.16(a), and 20 NMAC 4.1, Subpart V, 264.192(a) [1-1-97], a written assessment has been prepared attesting that the vitrification unit slab tanks are designed to have sufficient structural integrity and are acceptable for handling mixed waste. The written assessment, reviewed and certified by an independent, qualified, registered professional engineer, is included as Appendix 2 of this document.

In accordance with 20 NMAC 4.1, Subpart V, 264.192(d) [1-1-97], owners or operators of new tanks and ancillary equipment must ensure that the system is tested for tightness. The vitrification unit slab tanks will be tightness tested, at operating pressure (i.e., under a vacuum of 10 to 20 in. of mercury), upon completion of installation and prior to use. A signed certification will be prepared and will include the tightness-testing procedures adhered to during the tightness tests and the results of the tightness tests.

In accordance with 20 NMAC 4.1, Subpart V, 264.192(b) [1-1-97], owners or operators of new tank systems must ensure that proper handling procedures are adhered to during installation in order to prevent damage to the system. To ensure proper installation, the vitrification unit slab tanks will be inspected by a qualified inspector for weld breaks, punctures, scratches in the protective coatings, cracks, corrosion, and other structural damage or inadequate construction or installation. A signed certification attesting to the proper installation of the new tanks and a copy of the inspection checklist will be prepared in accordance with 20 NMAC 4.1, Subpart IX, 270.16(f), and 20 NMAC 4.1, Subpart V, 264.192(g) [1-1-97].

5.3 SECONDARY CONTAINMENT [20 NMAC 4.1, Subpart IX, 270.16(g); 20 NMAC 4.1, Subpart V, 264.193, 264.195(b), and 264.196]

The following provides a detailed description of the vitrification unit slab tanks secondary containment in accordance with 20 NMAC 4.1, Subpart IX, 207.16(g), and 20 NMAC 4.1, Subpart V, 264.193(a), (b), (c), (d), and (e)(1) [1-1-97]. The secondary containment system described below meets the requirements of an external liner system. TA-55-4, Room 434A will serve as secondary containment for the vitrification unit slab tanks and all ancillary equipment and piping upon installation. The walls and floor of this room will prevent the migration of wastes or accumulated liquids to any soil, groundwater, or surface water and are capable of collecting releases and accumulated liquids until the material is removed. Because the vitrification unit slab tanks and secondary containment are inside a building, run-on or precipitation will not affect the containment capacity. The capacity of the containment area will be sufficient to contain 100 percent of the capacity of the largest liquid-bearing container within its boundary. The floor of Room 434A is constructed of 10-in. thick concrete and will be coated with a chemical- and temperature-resistant epoxy primer and epoxy paint. This coating is compatible with the wastes stored in the vitrification unit slab tanks and will effectively prevent the migration of waste, if spilled, into the concrete. The construction joints in the floor slab and exterior walls are all constructed with chemical-resistant water stops in place. The conduit piping penetrating the floor of the room will be secured with rubber boots, bushings, and flanges. All penetrations (i.e., holes for conduit) in the floor will be sealed to prevent liquids from entering the penetrations. Figure 5-5 presents a structural drawing, which illustrates the first floor construction.

The vitrification unit slab tanks and the secondary containment will be inspected daily (when containing waste) to detect leaks, in accordance with 20 NMAC 4.1, Subpart V, 264.195(b) [1-1-97]. Additional leak detection will be provided by continuous air monitors (CAM) at various locations throughout Room 401. CAMs will detect any airborne alpha contamination that would be present

if a leak were to occur at any point in the system. Additionally, radiological control technicians periodically monitor for radioactive contamination and would detect any leaks during monitoring. Leaks or spills would be detected within 24 hours, as required by 20 NMAC 4.1, Subpart V, 264.193(c)(3) [1-1-97]. The secondary containment will be operated to remove leaks and spills. In the event of a leak or spill, the liquids will be removed as quickly as possible with sorbents and packaged in appropriate containers or vacuum-transferred, using the wet vacuum, into an available container. The collected materials will then be sampled, as necessary. If the accumulated liquids are from an identifiable source, the resulting material may be characterized as a newly-generated waste using acceptable knowledge or may be analyzed, as applicable, for the hazardous waste constituents known to be components of the source. If the accumulated liquids are from other than an identifiable source, the resulting material will be analyzed for the appropriate potential parameters listed in Table E.2-1 of Attachment E.2 of the permit modification request. Containers of collected liquids will be stored with secondary containment, pending analytical results, which determine how the waste liquids will be managed. This method of removal and analysis of accumulated liquids fulfills the requirements of 20 NMAC 4.1, Subpart V, 264.196 [1-1-97], for responses to leaks or spills.

If it is determined that there has been a leak or spill from the vitrification unit slab tanks or the secondary containment, they will be removed from service immediately and the requirements of 20 NMAC 4.1, Subpart V, 264.196 [1-1-97], will be initiated.

5.4 SPECIAL REQUIREMENTS FOR IGNITABLE, REACTIVE, AND INCOMPATIBLE WASTES [20 NMAC 4.1, Subpart IX, 270.16(j); 20 NMAC 4.1, Subpart V, 264.17, 264.198, and 264.199]

Currently, there are no plans to store ignitable, reactive, or incompatible waste in the vitrification unit slab tanks.

5.5 AIR EMISSION STANDARDS FOR EQUIPMENT LEAKS [20 NMAC 4.1, Subpart V, 264.1064(k); 40 CFR Part 264, Subpart BB]

The vitrification unit slab tanks are not subject to Title 40 of the Code of Federal Regulations (40 CFR), Part 264, Subpart BB [1-1-97], "Air Emission Standards for Equipment Leaks," with the exception of the reporting requirements specified in 20 NMAC 4.1, Subpart V, 264.1064(k) [1-1-97]. None of the components or ancillary equipment associated with the vitrification unit slab tanks will contain or contact mixed waste with organic concentrations of at least 10 percent by weight.

In accordance with 20 NMAC 4.1, Subpart V, 264.1064(k) [1-1-97], TA-55 will use knowledge of the nature of the evaporator bottoms solutions waste stream or knowledge of the process by which the evaporator bottoms solutions waste stream was produced to document exemptions to these standards. Production process information documenting that no organic compounds are contained in or contacted by the components and ancillary equipment associated with the vitrification unit slab tanks will be recorded in TA-55's facility operating record.

A new determination will be made whenever there is a change in a process at TA-55 that produces the evaporator bottoms solutions waste stream that could result in an increase in the total organic content of waste contained in or contacted by equipment currently determined not to be subject to these requirements.

5.6 ORGANIC AIR EMISSION STANDARDS [20 NMAC 4.1, Subpart V, 264.200; 40 CFR Part 264, Subpart CC]

Tanks which store only mixed waste are not subject to the requirements of 40 CFR, Part 264, Subpart CC, "Air Emission Standards for Tanks, Surface Impoundments, and Containers." Only mixed waste will be managed in the vitrification unit slab tanks; therefore, the vitrification unit slab tanks are not subject to 40 CFR, Part 264, Subpart CC.

Table 5-1

Regulatory References and Corresponding Location for the Vitrification Unit Slab Tanks

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§270.16	Information requirements for tank systems	5.0
§264.13	General waste analysis	Attachment A[a]
§264.191	Assessment of existing tank system's integrity	NA[b]
§270.16	Tank systems	5.0
§270.16(a)	Written assessment and certification	Appendix 2
§270.16(b)	Dimensions and capacity	5.1
§270.16(c)	Feed systems, safety cutoff, bypass systems, and pressure controls	5.1
§270.16(d)	Piping, instrumentation, and process flow diagrams	5.1, Figures 4-1 and 5-4
§270.16(e)	External corrosion protection	Appendix 2
§270.16(f)	Installation of new tank systems	5.2
§264.191	Assessment of existing tank system integrity	NA
§264.191(a)	Existing tank system w/o secondary containment	NA
§264.191(b)	Written assessment of structural integrity	NA
§264.191(b)(1)	Design standards	NA
§264.191(b)(2)	Hazardous characteristics of waste	NA
§264.191(b)(3)	Existing corrosion protection measures	NA
§264.191(b)(4)	Documentation of tank age	NA
§264.191(b)(5)	Results of leak test, internal inspection, or other tank integrity exam	NA
§264.191(d)	Assessment reveals leaking	NA
§264.192	Design and installation of new tank systems or components	5.1, 5.2
§264.192(a)	Written assessment of structural integrity	Appendix 2
§264.192(a)(1)	Design standards	Appendix 2
§264.192(a)(2)	Hazardous characteristics of waste	Appendix 2
§264.192(a)(3)(i)	Factors affecting the potential for corrosion	Appendix 2
§264.192(a)(3)(ii)	Corrosion protection measures	Appendix 2
§264.192(a)(4)	Determination of protection measures for underground tank system components	Appendix 2
§264.192(a)(5)	Design considerations	Appendix 2
§264.192(b)	Precautions to prevent damage during installation	5.2
§264.192(c)	Backfill requirements	NA
§264.192(d)	Tightness testing	5.2
§264.192(e)	Protection of ancillary equipment	5.1
§264.192(f)	Independent corrosion expert recommendations	NA

See footnotes at end of table.

Table 5-1 (continued)

Regulatory References and Corresponding Location for the Vitrification Unit Slab Tanks

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§264.192(g)	Certification of proper design and installation	5.2
§270.16(g)	Secondary containment systems	5.3
§264.193	Containment and detection of releases	5.3
§264.193(a)	Preventing the release of hazardous constituents to the environment	5.3
§264.193(a)(1)	Secondary containment of new tank systems	5.3
§264.193(a)(2)	Tank systems used to store or treat EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027, within two years after January 12, 1987	NA
§264.193(a)(3)	Existing tank systems of known and documented age, within two years after January 12, 1987 or when the tank system has reached 15 years of age	NA
§264.193(a)(4)	Existing tank systems for which the age cannot be documented, within eight years of January 12, 1987	NA
§264.193(b)	Secondary containment system requirements	5.3
§264.193(b)(1)	Design, installation, and operation to prevent migration of waste or accumulated liquid out of system to the environment	5.3
§264.193(b)(2)	Detection and collection of releases and accumulated liquids	5.3
§264.193(c)	Secondary containment construction requirements	5.3
§264.193(c)(1)	Compatible construction materials of sufficient strength and thickness	5.3
§264.193(c)(2)	Foundation	5.3
§264.193(c)(3)	Leak detection system	5.3
§264.193(c)(4)	Sloped or designed to remove liquids from leaks, spills, or precipitation	5.3
§264.193(d)	Secondary containment devices	5.3
§264.193(e)	Additional construction requirements	5.3
§264.193(e)(1)	External liner systems	5.3
§264.193(e)(2)	Vault systems	NA
§264.193(e)(3)	Double-walled tanks	NA
§264.193(f)	Ancillary equipment	5.3
§270.16(h)	Tank systems with a variance	NA
§264.193(g)	Variance from the requirements of §264.193	NA
§264.193(h)	Secondary containment variance request procedures	NA
§264.193(i)	Requirements pending provision of adequate secondary containment	NA

See footnotes at end of table.

Table 5-1 (continued)

Regulatory References and Corresponding Location for the Vitrification Unit Slab Tanks

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§264.194	General operating requirements	5.1, 5.3
§264.194(a)	Prohibition of hazardous waste that could cause the tank or equipment to rupture, leak, corrode, or otherwise fail	5.1, Appendix 2
§270.16(i)	Description of controls and practices to prevent spills and overflows	5.1
§264.194(b)	Controls and practices to prevent spills and overflows	5.1
§264.194(b)(1)	Spill prevention controls	5.1
§264.194(b)(2)	Overfill prevention controls	5.1
§264.194(b)(3)	Maintenance of sufficient freeboard	NA
§264.195	Inspections	Attachment B[a]
§264.195(a)	Overfill control inspection schedule	Attachment B[a]
§264.195(b)	Inspection of tank system for corrosion or releases, data from monitoring and leak detection equipment, construction materials, and immediately surrounding area	5.3, Attachment B[a]
§264.195(c)	Inspection of cathodic protection system	NA
§264.196	Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	5.3
§264.196(a)	Cessation of use	5.3
§264.196(b)	Removal of waste	5.3
§264.196(c)	Containment of visible releases to the environment	5.3
§264.196(d)	Notifications, reports	5.3
§264.196(e)	Provisions for repair	5.3
§264.196(f)	Certification of major repairs	5.3
§264.197	Closure and post-closure care	Attachment E.2[a]
§264.197(a)	Removal and decontamination of all hazardous waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment	Attachment E.2[a]
§264.197(b)	Demonstration that not all contaminated soils can be practicably removed or decontaminated	NA
§264.197(c)	Tank system not having secondary containment that meets the requirements of §264.193(b) through (f) and has not been granted a variance from the secondary containment requirements	NA
§264.197(c)(1)	Plan for complying with removal and decontamination requirements	Attachment E.2[a]

See footnotes at end of table.

Table 5-1 (continued)

Regulatory References and Corresponding Location for the Vitrification Unit Slab Tanks

Regulatory Citation(s)	Description of Requirement	Location in this Document or the Permit Modification Request
§264.197(c)(2)	A contingent post-closure plan	Attachment E.2[a]
§264.197(c)(3)	Cost estimates calculated for closure and post-closure care	Attachment E.2[a]
§264.197(c)(4)	Financial assurance based on cost estimates	Attachment E.2[a]
§264.197(c)(5)	Contingent closure and post-closure plans must meet all of the closure, post-closure, and financial responsibility requirements for landfills	Attachment E.2[a]
§270.16(j)	Special requirements for ignitable, reactive, or incompatible wastes	5.4
§264.198	Special requirements for ignitable or reactive wastes	5.4
§264.198(a)	Circumstances allowing ignitable or reactive waste in tanks	NA
§264.198(a)(1)	The waste is treated, rendered, or mixed before or immediately after placement in the tank system	NA
§264.198(a)(1)(i)	The resulting waste, mixture, or dissolved material no longer meets the definition of ignitable or reactive waste	NA
§264.198(a)(1)(ii)	Compliance with §264.17(b)	NA
§264.198(a)(2)	The waste is stored or treated in such a way that it is protected from any material or conditions that may cause the waste to ignite or react	NA
§264.198(a)(3)	The tank system is used solely for emergencies	NA
§264.198(b)	Compliance with the requirements for the maintenance of protective distances between the waste management area and any public ways, streets, alleys, or an adjoining property line	NA
§264.199	Special requirements for incompatible wastes	5.4
§264.199(a)	Incompatible wastes, or incompatible wastes and materials, must not be placed in the same tank system, unless §264.17(b) is complied with	5.4
§264.199(b)	Hazardous waste must not be placed in a tank system that has not been decontaminated and that previously held an incompatible waste or material, unless §264.17(b) is complied with	5.4
§270.16(k)	Air emission control equipment	5.5, 5.6
§270.27	Information requirements for air emission controls	5.5, 5.6
§264.200	Air emission standards	5.5, 5.6

[a] Located in the "Los Alamos National Laboratory Technical Area 55 Vitrification Unit and Vitrification Unit Slab Tanks Permit Modification Request."

[b] NA = not applicable.

Figures 5-1 through 5-5 have been provided confidentially under separate cover.

6.0 RECORDKEEPING REQUIREMENTS

Recordkeeping requirements applicable to the vitrification unit and vitrification unit slab tanks are discussed in the following sections.

6.1 BIENNIAL REPORT [20 NMAC 4.1, Subpart V, 264.75]

Los Alamos National Laboratory (LANL) will prepare and submit a biennial report to the New Mexico Environment Department (NMED) by March 1 of each even-numbered year. The biennial report will be submitted to the NMED on U.S. Environmental Protection Agency (EPA) Form 8700-13B (revised July 1997). The report will cover facility activities during the previous calendar year and will include:

- The EPA identification number, name, and address of the facility;
- The calendar years covered by the report;
- A description and the quantity of each mixed waste the facility received during the year;
- The method of treatment, storage, or disposal for each mixed waste;
- For generators who treat, store, or dispose of mixed waste on site, a description of the efforts undertaken during the year to reduce the volume and toxicity of waste generated;
- For generators who treat, store, or dispose of mixed waste on site, a description of the changes in volume and toxicity of waste actually achieved during the year in comparison to previous years to the extent such information is available for the years prior to 1984; and
- The certification signed by LANL or an authorized representative.

6.2 UNMANIFESTED WASTE REPORT [20 NMAC 4.1, Subpart V, 264.76]

The requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, 264.76, revised January 1, 1997 [1-1-97], are not applicable because TA-55 will not accept waste from off-site sources for treatment or storage in the vitrification unit or vitrification unit slab tanks.

6.3 ADDITIONAL REPORTS [20 NMAC 4.1, Subpart V, 264.77]

In accordance with the requirements of 20 NMAC 4.1, Subpart V, 264.77 [1-1-97], LANL will also report the following to the NMED:

- Releases and unanticipated fires, and explosions that require implementation of the contingency plan, as specified in 20 NMAC 4.1, Subpart V, 264.56(j) [1-1-97];

- Facility closures, as specified in 20 NMAC 4.1, Subpart V, 264.115 [1-1-97]; and
- As otherwise required by 20 NMAC 4.1, Subpart V, Part 264, Subpart F [1-1-97], and Title 40 of the Code of Federal Regulations, Part 264, Subparts BB and CC.

7.0 CORRECTIVE ACTION FOR SOLID WASTE MANAGEMENT UNITS

The information provided in this section is submitted to address the applicable solid waste management unit (SWMU) requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.14(d), revised January 1, 1997 [1-1-97]. This section provides descriptions of the SWMUs identified at Technical Area (TA) 55. Information on these SWMUs was extracted from Revision 1.0 of the Los Alamos National Laboratory (LANL) "Solid Waste Management Units Report" (LANL, 1990), hereinafter referred to as the 1990 SWMU Report, and the "RFI Work Plan for Operable Unit 1129" (LANL, 1992).

LANL uses the definition of a SWMU presented in "Module VIII: Special Conditions Pursuant to the 1984 Hazardous and Solid Waste Amendments to RCRA for Los Alamos National Laboratory, EPA I.D. NM0890010515" (U.S. Environmental Protection Agency [EPA], 1994), hereinafter referred to as Module VIII. This definition states that SWMUs are "any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released."

7.1 TA-55 GENERAL SWMU DESCRIPTIONS [20 NMAC 4.1, Subpart IX, 270.14(d)(1)]

Several types of SWMUs have been identified at TA-55 and are described below. These include SWMUs identified for corrective actions in Module VIII, as modified following a Class 3 permit modification effective December 23, 1998 (New Mexico Environment Department [NMED], 1998); and SWMUs that are Resource Conservation and Recovery Act (RCRA) active hazardous/mixed waste management units. Brief unit and waste descriptions are also provided in Table 7-1. Figure 7-1 shows the locations of the SWMUs in TA-55.

TA-55 contains SWMUs associated with TA-42, an inactive TA, which was located within the current TA-55 boundary. From 1951 until 1978, TA-42 was located within a 5,000-square-meter fenced area just to the northeast of the main cluster of buildings currently located at TA-55. In 1978, all structures, debris, and soil contamination associated with TA-42 were removed and taken to TA-54 during a decontamination and decommissioning (D&D) project (LANL, 1992).

7.1.1 SWMUs Identified for Corrective Action in Module VIII

The following are descriptions of the SWMUs at TA-55, including the SWMUs associated with the former TA-42, that have been identified for corrective action in Module VIII, as modified in 1998.

7.1.1.1 Incinerator Complex

SWMU No. 42-001(a) is identified as an incinerator designed to incinerate radionuclide-contaminated waste in a cylindrical combustion chamber. The incinerator was located at TA-42, Building 1 (TA-42-1) adjacent to the north wall. Beginning in 1951, the unit was used to incinerate small quantities of low-level radioactive waste. Because of operational problems, however, the incinerator was shut down in 1952 (LANL, 1992). Part of the building (TA-42-1) was later used as a decontamination and storage area. The entire structure was removed in 1978.

SWMU Nos. 42-001(b) and (c) are identified as two holding tanks that were located immediately north of the incinerator at TA-42. The tanks each had a 37,000-gallon capacity and were connected to the incinerator via underground drainlines. The tanks, which were used to store ash generated during the incineration process, were removed during the 1978 D&D project. The drainlines were filled with asphalt, but it remains unknown whether they were removed or left in place (LANL, 1992).

7.1.1.2 Decontamination Area

SWMU No. 42-002(b) is identified as an outside decontamination area located at the end of an asphalt driveway, to the north and west of TA-42-1. Between 1956 and 1969, this area was used to decontaminate items that were too large for decontamination in TA-42-1. Runoff from decontamination activities flowed down an embankment on the northwest side of the driveway and is estimated to have potentially contaminated an approximate area of 75 feet (ft) by 100 ft. Potentially contaminated soils were not sampled or removed during the 1978 D&D project (LANL, 1992).

7.1.1.3 Septic System

SWMU No. 42-003 is a septic system that was located near and served TA-42-1. Installed in 1951, the septic system consisted of a drainline from the building, a 565-gallon septic tank, a filter trench, a leach field, and an outfall to Mortandad Canyon (LANL, 1990; LANL, 1992). The septic system encompassed an area of approximately 75 ft by 200 ft. Liquid wastes containing plutonium, uranium, fission products, and tritium entered the septic system as a result of the decontamination activities conducted in TA-42-1. Solvents, acids, and greases may have also entered the septic system. The septic system and associated contaminated soils were removed in 1978 during the D&D project (LANL, 1992).

7.1.1.4 Sumps, Pumps, and Tanks

SWMU No. 55-008 is collectively identified as the sumps, pumps, and tanks in the TA-55-4 basement. Six 3- by 3- by 3-ft deep sumps collect spills and mop water generated in the building. The liquid may contain mixed waste constituents (LANL, 1990). Four condensate tanks, each measuring 8 inches (in.) in diameter and 4 ft long, and four blowdown tanks of the same dimensions, receive condensate from cooling coils. The condensate discharged to the units may have contained small amounts of mixed waste in the past. All liquids collected and contained within these units are transferred via direct pipeline to TA-50 for treatment (LANL, 1990; LANL, 1992). Operations began at TA-55-4 in 1978 and continue until present.

7.1.1.5 Monitoring Sump

SWMU No. 55-009 consists of a sump located northeast and outside of TA-55-6. The sump, which is no longer in service, was used to monitor sanitary waste liquids produced at TA-55 prior to being discharged to sewage treatment lagoons at TA-35. The sump measures approximately 7 ft long, 7 ft wide, and 5.5 ft deep and is connected to TA-55-4 by a 6-in. vitrified clay pipe measuring approximately 250 ft long. An 8-in. vitrified clay pipe, measuring approximately 4,000 ft long, connected the sump to the lagoons at TA-35. The sump was in service for several years, but no significant levels of radionuclides were ever detected. This unit was taken out of service and abandoned in place (LANL, 1990; LANL, 1992).

7.1.2 Active Hazardous/Mixed Waste Management Units Not Identified in Module VIII

The following sections provide descriptions of the SWMUs that are not included in Module VIII, as modified in 1998, and are active hazardous/mixed waste management units operating under interim status standards.

7.1.2.1 Cementation Unit

SWMU No. 55-001, the cementation unit, is located in Room 401 in the southwest corner of the TA-55-4 and occupies an area of approximately 2 ft by 9 ft. The cementation unit is used to treat mixed waste generated at TA-55. The cementation unit became operational in approximately 1980 (LANL, 1990).

SWMU No. 55-001 also includes the cementation unit pencil tanks, which are used for storage of mixed waste prior to solidification.

7.1.2.2 Evaporator Glovebox Tank

SWMU No. 55-004 consists of the evaporator glovebox tank located in Room 401 in TA-55-4 and occupies an area of approximately 4 ft by 12 ft. The evaporator glovebox tank stores evaporator bottoms solutions waste prior to solidification. The evaporator glovebox tank began operation in approximately 1980.

7.1.2.3 Container Storage Locations

The following locations are used for hazardous and/or mixed waste storage and are operated under interim status standards. These container storage locations have not been formally designated as SWMUs nor assigned SWMU numbers.

The basement in TA-55-4 has six container storage locations designated as storage locations B40, B38, B05, K13, B45, and the Vault. Storage location B40 is L-shaped, located in the southwest section of the basement, and is approximately 61 ft long by 55 ft wide. Storage location B38 is located in the southeast section of the TA-55 basement and is approximately 27 ft long by 11 ft wide. Storage location B05 is located in the southwest section of the TA-55-4 basement and is approximately 26 ft long by 10 ft wide. Storage location K13 is located in the northwest section of the TA-55-4 basement and is 16 ft long by 13 ft wide. Storage location B45 is located in the northeast section of the basement and is approximately 45 ft long by 17.5 ft wide. The Vault is located along the eastern wall of the TA-55-4 basement and is approximately 80 ft long by 50.5 ft wide. Storage locations B40, B38, B05, K13, and B45 may be used to store hazardous waste, mixed low-level waste, and mixed transuranic (TRU) waste. The only waste items that may be stored in the Vault are mixed low-level or mixed TRU waste.

At TA-55-185, an area measuring approximately 60 ft long by 18 ft wide, may be used to store hazardous waste, mixed low-level waste, and mixed TRU waste.

An asphalt storage pad, which is located on the west side of TA-55-4, is used to store containers. This pad has a trapezoidal shape with the four sides measuring 102 ft, 86 ft, 156 ft, and 105 ft. The pad is used to store hazardous waste, mixed low-level waste, and mixed TRU waste.

7.2 RELEASES [20 NMAC 4.1, Subpart IX, 270.14(d)(2)]

At SWMU Nos. 42-001(b) and (c), liquid waste and ash waste were intentionally released from the holding tanks into Mortandad Canyon in 1952. The ash waste contained an estimated 100

milliCuries of radioactivity. Samples collected from Mortandad Canyon in 1952 confirmed that radioactive contamination had entered the canyon (LANL, 1992).

At SWMU No. 42-002(b), wash liquids from the outdoor contamination area were not contained and ran down an embankment adjacent to the asphalt driveway. Potentially affected soils were not sampled or removed during the D&D project (LANL, 1990; LANL, 1992).

SWMU No. 42-003, a septic system, released radioactive liquid wastes to an outfall area in Mortandad Canyon. During the 1978 D&D project, approximately 1,200 cubic meters of soil were removed from the septic tank outfall area. Analysis of soil samples collected in the outfall area indicated levels of radioactivity ranging from below 25 picoCuries per gram (pCi/g) to 400 pCi/g (LANL 1990; LANL, 1992).

7.3 CHARACTERIZATION OF RELEASE

Potential releases from SWMUs are described in the 1990 SWMU Report (LANL, 1990) and in the "RFI Work Plan for Operable Unit 1129" (LANL, 1992). These descriptions include the material released and the nature of the release. However, because of the nature of the releases, the exact volume released is not known. The timing of the releases can only be estimated by the period of operation and sampling events.

7.4 CORRECTIVE ACTIONS [20 NMAC 4.1, Subpart V, 264.101(a)]

Pursuant to 20 NMAC 4.1, Subpart V, 264.101(a) [1-1-97], corrective actions are required only for releases of hazardous waste or hazardous constituents. The SWMUs will be investigated with EPA and NMED approval during LANL Environmental Restoration Project corrective action activities. Corrective action, if necessary, will generally follow the RCRA Facility Investigation/Corrective Measures Study process. RCRA Facility Investigation Work Plans have been completed for TA-42 and TA-55.

Table 7-1

Technical Area (TA) 55 Solid Waste Management Unit (SWMU) Descriptions[a]

SWMU No.	Unit Type	Unit Description	Waste Description
42-001(a)[b]	Incinerator	Cylindrical combustion chamber housed in Technical Area (TA)-42-1 and used to incinerate radioactively-contaminated waste; decommissioned in 1978.	Radioactively-contaminated waste.
42-001(b-c)[b]	Holding Tanks	Two 37,000-gallon holding tanks associated with the incinerator; decommissioned in 1978.	Radioactive ash from the incinerator.
42-002(b)[b]	Decontamination Area	Asphalt driveway formerly located adjacent to TA-42-1 and used to decontaminate large items that could not be decontaminated inside TA-42-1; decommissioned in 1978.	Radionuclides and possibly grease and oils.
42-003[b]	Septic System	Septic system that served TA-42-1; the unit consisted of a drainline from TA-42-1, a 565-gallon septic tank, a filter trench, a leach field, and an outfall; decommissioned in 1978.	Sanitary wastes and liquid wastes containing plutonium, uranium, fission products, tritium, and possibly solvents, acids, and greases.
55-001	Cementation Unit and Storage Tanks	Cementation unit housed inside a glovebox in TA-55-4-401. Five storage tanks and ancillary equipment associated with the cementation unit in TA-55-4-401.	Hazardous waste, mixed transuranic (TRU) waste, and mixed low-level waste.
55-004	Storage Tank	Evaporator glovebox tank and ancillary equipment associated with the evaporator in TA-55-4-401.	Mixed TRU waste liquid.
55-008[b]	Sumps, Pumps and Tanks	Sumps, pumps, and tanks used to contain and manage spills, mop water, and cooling coil condensate generated in TA-55-4.	Potentially small amounts of mixed wastes.
55-009[b]	Sump	Inactive sump formerly used to monitor sanitary waste liquids produced at TA-55.	Sanitary wastes that may have contained radioactively-contaminated liquids.
TBD[c]	Container Storage	An approximately 61- by 55-foot (ft) area adjacent to Room 42 in the southwest quadrant of the TA-55-4 basement (B40).	Hazardous waste, mixed TRU waste, and mixed low-level waste.
TBD[c]	Container Storage	An approximately 27- by 11-ft area adjacent to Room 38A in TA-55-4 basement (B38).	Hazardous waste, mixed TRU waste, and mixed low-level waste.
TBD[c]	Container Storage	An approximately 26- by 10-ft area located in southwest quadrant of TA-55-4 basement (B05).	Hazardous waste, mixed TRU waste, and mixed low-level waste.

See footnotes at end of table.

Table 7-1 (continued)

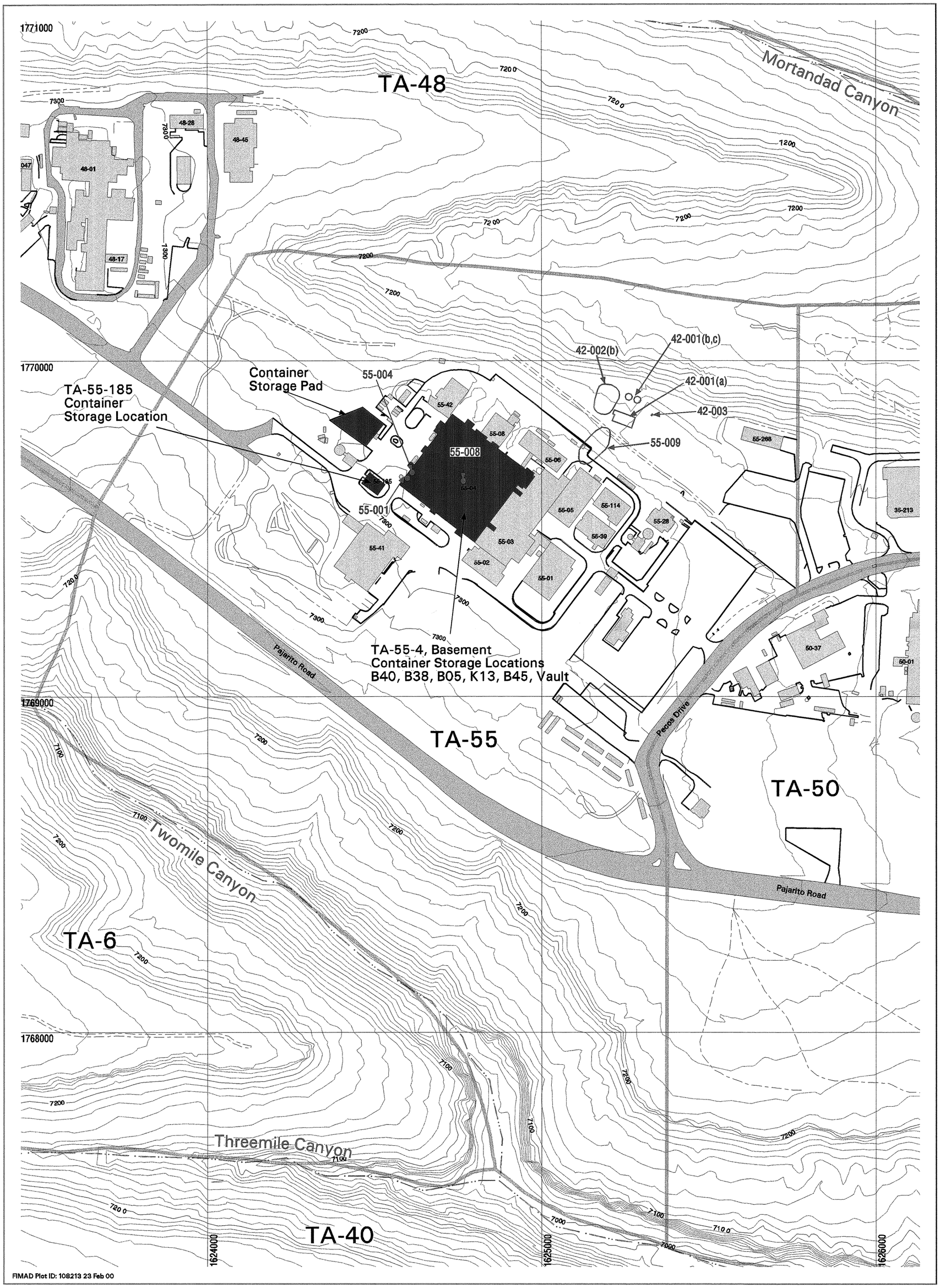
Technical Area (TA) 55 Solid Waste Management Unit (SWMU) Descriptions[a]

SWMU No.	Unit Type	Unit Description	Waste Description
TBD[c]	Container Storage	An approximately 16- by 13-ft area located north of Room 7 in the northwest corner of TA-55-4 basement (K13).	Hazardous waste, mixed TRU waste, and mixed low-level waste.
TBD[c]	Container Storage	An approximately 45- by 17.5-ft area adjacent to Room 8 in the northeast section of TA-55-4 basement (B45).	Hazardous waste, mixed TRU waste, and mixed low-level waste.
TBD[c]	Container Storage	An approximately 80- by 50.5-ft area located along the eastern wall of the TA-55-4 basement (Vault).	Mixed TRU waste and mixed low-level waste.
TBD[c]	Container Storage	An approximately 60- by 18- ft area in TA-55-185.	Hazardous waste, mixed TRU waste, and mixed low-level waste.
TBD[c]	Container Storage	Trapezoidal-shaped asphalt pad located on the west side of TA-55-4; the four sides of the pad measure 102 ft, 86 ft, 156 ft, and 105 ft.	Hazardous waste, mixed TRU waste, and mixed low-level waste.

[a] Information compiled from Los Alamos National Laboratory, 1990, "Solid Waste Management Units Report," Revision 1.0, *LAUR 90-3400*, Los Alamos National Laboratory, Los Alamos, New Mexico; and Los Alamos National Laboratory, 1992, "RFI Work Plan for Operable Unit 1129," *LAUR-92-800*, Los Alamos National Laboratory, Los Alamos, New Mexico.

[b] SWMU is identified for corrective action in New Mexico Environment Department, 1998, "Approval: Class III Permit Modification to Remove Ninety-Nine (99) Solid Waste Management Units from the Department of Energy/Los Alamos National Laboratory RCRA Permit NM0890010515," effective December 23, 1998, New Mexico Environment Department, Hazardous and Radioactive Materials Bureau.

[c] TBD - SWMU number to be determined.



LEGEND

- Boundary, TA
- Contour, 10 foot
- Contour, 100 foot
- Road, Paved
- Road, Dirt
- Road/Trail
- Stream, Intermittent
- Stream, Perennial
- SWMU Location
- SWMU, Point Location
- Structure
- Storage Locations for Hazardous and/or Mixed Waste

PERCHED ALLUVIAL MONITORING WELLS
(Old wells are pre-1990, new wells installed since 1990 according to EPA guidelines)

- New Dry Well
- Old Dry Well
- New Saturated Well
- Old Saturated Well

MAIN AQUIFER WELLS

- Water Supply Well
- Test Well

OTHER

- Abandoned/Plugged Well
- LAOR Well
- Other Monitoring Well

- Surface Water Sampling Station
- Spring

Figure 7-1. Solid Waste Management Units (SWMU) at Technical Area (TA) 55

4450-E

University of California
Los Alamos National Laboratory
Earth and Environmental Sciences Division

EES-5 GIS TEAM

Produced by: Marcia Jones
Date: February 23, 2000 GIS Plot ID: G108213

N

State Plane Coordinate System, New Mexico Central Zone.
1983 North American Datum

Grid provides NM State Plane coordinates in feet.
Grid interval, in feet: 1000
Feet per inch on map = 200

SCALE 1:2400

0 61 122 183 244
METERS
0 200 400 600 800
FEET

Notice: The information on this map is provisional and the accuracy has not been confirmed. Feature locations are dependent on scale and symbology and should not be relied upon to establish legal claims. Basemap Sources: Boundary, structure, and utility data are from Los Alamos National Laboratory Engineering Division and Los Alamos County Utility and Engineering Departments. Contour data is from Los Alamos National Laboratory Environmental Restoration Program aerial survey, September 1991.

8.0 OTHER FEDERAL LAWS

The following federal laws are required under the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart IX, 270.3 and 270.14(b)(20), revised January 1, 1997 [1-1-97], to be given consideration when applying for a hazardous waste facility permit. When any of these laws are applicable, its procedures must be followed:

1. *The Wild and Scenic Rivers Act (16 United States Code [USC] 1273 et seq.).* This act provides for a national wild and scenic rivers system and prohibits construction of any waterway that would have a direct adverse effect on the values for which a wild and scenic river was established.

2. *The National Historic Preservation Act of 1966 (16 USC 470 et seq.).* This act establishes a program for the preservation of historic properties throughout the country. The act has provisions that require mitigation of adverse effects to registered properties.

3. *The Endangered Species Act of 1973 (16 USC 1531).* This act provides for the conservation of endangered and threatened species of fish, wildlife, and plants. The act prohibits any action that would jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat.

4. *The Coastal Zone Management Act of 1972 (16 USC 1451 et seq.).* This act establishes national policy for the management, use, protection, and development of land and water resources of the nation's coastal zones. Section 307(c) of the act and implementing regulations prohibit the U.S. Environmental Protection Agency from issuing a permit for activity affecting coastal zone land or water without the certification from the applicant that the activity is in compliance with the state Coastal Zone Management Program.

5. *The Fish and Wildlife Coordination Act of 1934, as amended (16 USC 661 et seq.).* This act promotes the conservation of wildlife, fish, and game and integrates this conservation with water resource projects. Certain provisions of the act require that permits proposing or authorizing the impoundment, diversion, or other control or modification of any body of water be considered by the appropriate state agency for impacts to wildlife resources.

Because Los Alamos National Laboratory (LANL) has ongoing programs in support of the National Historic Preservation Act, the Endangered Species Act, and the Fish and Wildlife Coordination Act, consideration was given to these federal laws. Provisions in the Wild and Scenic Rivers Act and the Coastal Zone Management Act are not applicable to LANL's activities.

Consideration will be given to Executive Orders, issued by the President, that are relevant to waste management activities at LANL. When any of these Orders is applicable, its provisions will be followed. Requirements for Executive Orders are reserved in 20 NMAC 4.1, Subpart IX, 270.3(f) [1-1-97].

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Appendix 1

"Glass Development for Treatment of LANL Evaporator Bottoms Waste,"
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PNNL-11865
UC-510

Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Glass Development for Treatment of LANL Evaporator Bottoms Waste

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AD-510

Glass Development for Treatment of LANL Evaporator Bottoms Waste

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September, 1998

Summary

Vitrification is currently being explored as an option for plutonium waste immobilization because of its ability to convert plutonium-bearing materials into a safe, durable, and accountable waste form with reduced need for safeguarding. A glass frit composition was developed for a widely varying evaporator bottoms waste from Los Alamos National Laboratory (LANL). The glass was optimized to allow maximum variation in waste composition while maintaining acceptable product quality and processability. Property-composition relationships based on measured viscosity and leach resistance (toxicity characteristic leach procedure) data were used to optimize the glass. All glass property measurements were made on glasses with cerium used as a surrogate for plutonium. The methods and data used to develop the optimized glass composition are reported.

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Introduction

Vitrification is an attractive treatment option for meeting the stabilization and final disposal requirements of many plutonium (Pu) bearing materials and wastes at the Los Alamos National Laboratory (LANL) TA-55 facility, Rocky Flats Environmental Technology Site (RFETS), Hanford, and other Department of Energy (DOE) sites. The Environmental Protection Agency (EPA) has declared that vitrification is the "best demonstrated available technology" for high-level radioactive wastes (HLW) (Federal Register 1990) and has produced a handbook of vitrification technologies for treatment of hazardous and radioactive waste (US EPA, 1992). This technology has been demonstrated to convert Pu-containing materials (Kormanos, 1997) into durable (Lutze, 1988) and accountable (Forsberg, 1995) waste forms with reduced need for safeguarding (McCullum, 1996). The composition of the Evaporator Bottoms Waste (EVB) at LANL, like that of many other Pu-bearing materials, varies widely and is generally unpredictable. The goal of this study is to optimize the composition of glass for EVB waste at LANL, and present the basic techniques and tools for developing optimized glass compositions for other Pu-bearing materials in the complex.

This report outlines an approach for glass formulation with fixed property restrictions, using glass property-composition databases. This approach is applicable to waste glass formulation for many variable waste streams and vitrification technologies. Also reported are the preliminary property data for simulated evaporator bottom glasses, including glass viscosity and glass leach resistance using the Toxicity Characteristic Leaching Procedure (TCLP).

Approach

The approach to waste glass formulation has been under development at PNNL for several years (Hrma et al. 1994, Hrma 1994, Vienna et al. 1997, Hrma et al. 1996, Vienna et al. 1997). Piepel et al. (1997) described the steps to develop a qualified glass composition region based on experimental data. This general approach to glass formulation was used to develop a frit composition for EVB waste vitrification. A slightly modified (compared to Piepel et al. 1997) set of steps for this method is listed below.

Step 1. Identify a Waste Composition Uncertainty Region (WCUR) that is expected to include the true range of waste compositions.
Step 2. Specify the acceptability constraints on glass composition, glass quality properties, and glass processing properties.
Step 3. Define a Glass Composition Experimental Region (GCER) containing glass compositions that might be made from wastes in the WCUR.
Step 4. Construct an experimental design that augments any relevant existing composition-property data with new compositions to adequately cover the GCER.
Step 5. Melt the new glass compositions from the experimental design and measure their glass properties.
Step 6. Fit property-composition relationships to new and existing data to enable prediction.
Step 7. Validate property-composition relationships with data not used in their development.

Step 8. Develop glass formulations by interpolation of glass property data (using defined constraints, waste compositions, and property-composition relationships).
Step 9. Validate glass acceptability and property predictions with experimental study.

This process can be, and often is, an iterative one. The optimization of a glass frit composition for vitrifying the widely varying LANL EVB waste stream, following steps 1-8 above, is discussed below.

Waste Compositions *(Step 1)*

EVB is transuranic waste remaining after evaporating the nitric acid-based effluent from ion-exchange processes at the TA-55 plutonium processing facility. Six types of EVB waste – hot distillate (HD), oxalate filtrate (OX), lean residue (LR), ATLAS (ATL), dissolution (DS), and chloride (CL) – were characterized by analysis of 324 samples. The samples were taken from homogeneous solutions, and analyzed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) for major components, by cold vapor atomic fluorescence for Hg, by germanium gamma spectrometer for Am, and by alpha proportional counter for Pu. Appendix A tabulates the measured waste compositions.

The analytical method left several gaps in the analysis of major waste components, including Al, Ca, Cr, Fe, K, Mg, and Na. A missing value in one of these major components would significantly alter the waste composition when the concentrations are normalized to wt% oxides. The affected waste compositions were therefore either removed from consideration, or were altered by substituting the average component concentration for the missing component. Waste compositions with missing data on one or more of the major components were deleted if the concentrations of the existing major components were within the ranges of other wastes of their type. Of the 324 original compositions, 130 such compositions were deleted, leaving 194 compositions. Alternatively, the average concentration from wastes in a specific waste type was substituted for a missing major component. This occurred with five compositions – 10EVDIST27BF1, EVDIS062596B2, EVOX041096B1, EVDS030896A1, and EVDS012297B1. Deleted waste compositions and substituted major component values are marked in Appendix A. Two of the waste types (ATL and CL) were not considered, since they are not typical of future waste streams. These two types contained 31 compositions, leaving 163 compositions for consideration. Table I summarizes the composition range for the remaining 163 waste compositions, including the minimum, maximum, mean, median, standard deviation, and 10th and 90th percentiles for the oxide component concentrations. The summary statistics in Table I indicate that the distributions of some component values are skewed (not symmetric) or have outlying values.

Table I. Evaporator bottom waste composition summary in wt% oxides

	Min	Mean	Median	Max	10%	90%	std dev
Ag_2O	0.00	0.00	0.00	0.01	.000	.001	0.00
Al_2O_3	0.00	3.34	2.62	45.60	1.46	5.10	4.25
Am_2O_3	0.00	0.03	0.02	0.13	0.01	0.05	0.02
As_2O_3	0.00	0.01	0.00	0.07	.000	.009	0.01
BaO	0.00	0.01	0.01	0.12	0.00	0.03	0.02
BeO	0.00	0.18	0.08	1.40	0.00	0.51	0.29
CaO	0.00	23.28	23.70	62.72	13.4	30.0	7.53
CdO	0.00	0.00	0.00	0.12	0.00	0.00	0.01
Cr_2O_3	0.32	2.69	2.24	10.71	1.35	4.60	1.57
Fe_2O_3	0.00	11.31	9.51	41.24	5.63	19.2	6.47
K_2O	0.00	14.21	12.91	44.42	3.50	23.6	8.14
MgO	0.00	40.07	39.11	92.57	25.9	51.8	13.10
Na_2O	0.06	2.99	1.11	59.09	0.50	5.33	7.08
NiO	0.03	1.36	1.10	6.41	0.70	2.22	0.85
PbO	0.01	0.10	0.07	0.51	0.03	0.19	0.08
PuO_2	0.00	0.38	0.23	2.52	0.12	0.84	0.38
TlO_x	0.00	0.02	0.01	0.25	0.01	0.03	0.03
U_3O_8	0.00	0.02	0.01	0.10	0.01	0.03	0.02

Figure 1 shows a scatter plot matrix of the seven major components (Al, Ca, Cr, Fe, K, Mg, and Na) for the final 163 waste compositions. In general, waste compositions are very diverse. However, many of the wastes cluster, leaving several outlying waste compositions. Examples of outlying wastes are the two highest Al wastes and the seven highest Na wastes. The strong correlation between Cr and Fe suggests that those two components are products of dissolved steel. Additional investigation of the Ni levels supports this thesis.

Glass Constraints *(Step 2)*

For vitrification to be successful, a glass must be developed that is processable, durable, and tolerant to changing or uncertain waste composition. The uncertainty and variation of waste composition is a challenging aspect to glass formulation. Alkaline and alkaline earth oxides (Na_2O, K_2O, CaO, and MgO) tend to decrease glass durability and viscosity (at melting temperature), while refractories (e.g., Al_2O_3 and SiO_2) increase glass durability and viscosity. Wide variation in the concentrations of these components will alter the glass processability and quality. For the EVB wastes, the concentrations of alkaline, alkaline earth, and aluminum oxides in the waste range from 1-60 wt%, 0-96 wt%, and 0-46 wt%, respectively. These diverse wastes are expected to be vitrified with a single frit composition at a single waste loading (WL) or fraction of waste in the glass. The ability to make processable and acceptable glass out of the diverse wastes ultimately determines the allowable WL.

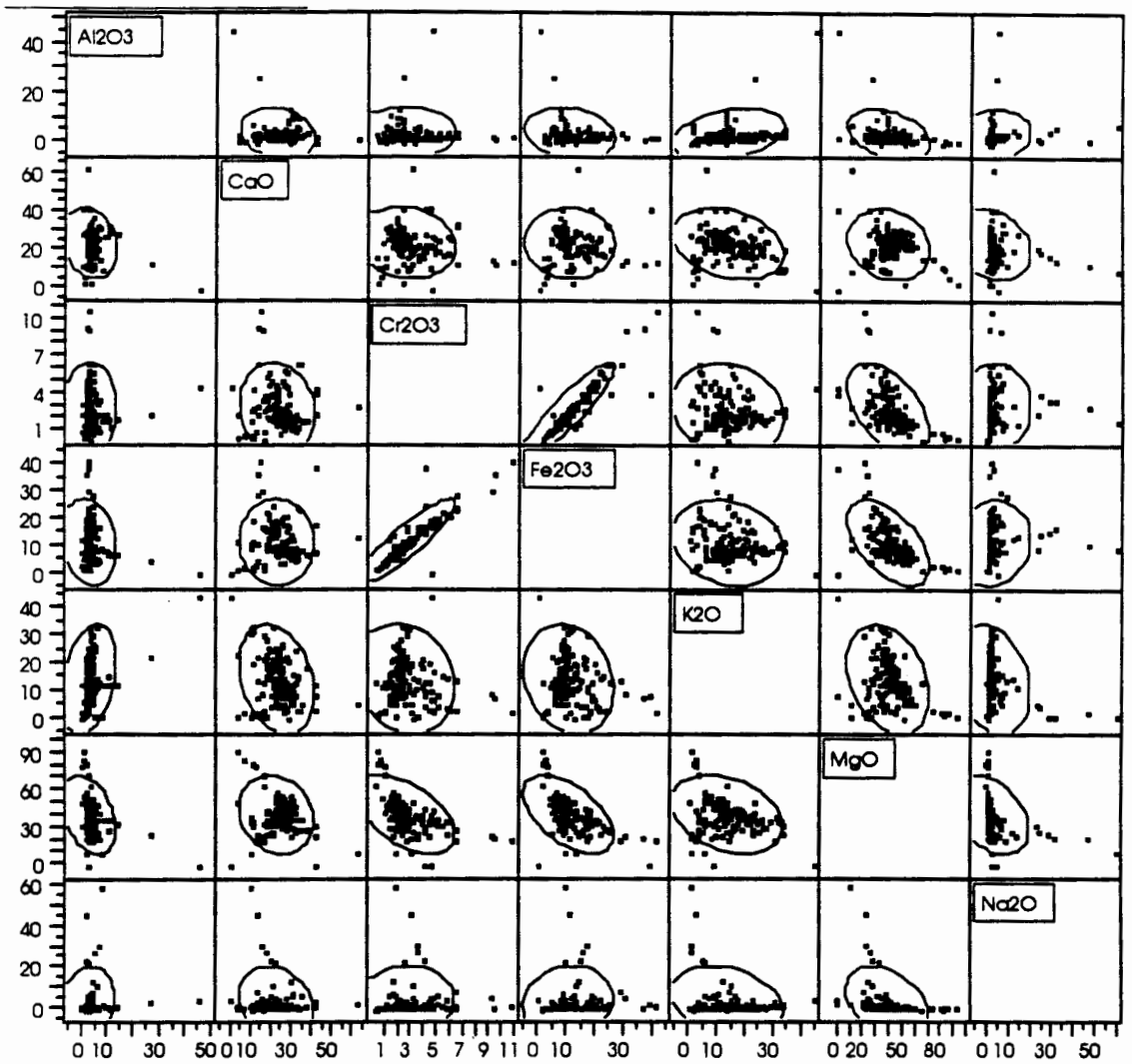

Figure 1. Scatter plot matrix of 163 waste compositions in wt% oxides (lines represent 95% bivariate normal density ellipses)

This waste is to be disposed of in the Waste Isolation Pilot Project (WIPP) and is restricted by the WIPP waste acceptance criteria (WAC). The WIPP WAC doesn't specify a durability constraint on waste material. However, to ensure a durable waste form for interim storage, the Toxicity Characteristic Leach Procedure (TCLP) was used as a leach resistance criterion for these glasses. The release of hazardous metals (including As, Ba, Cd, Cr, Pb, Hg, Se, and Ag) will be restricted to below the universal treatment standards (UTS) accepted levels for TCLP leaching (US EPA, 1997). This is a significantly more stringent standard than is required to ensure acceptability and safe storage these wastes. However, this does not limit the acceptability of many wastes, and has no impact on waste loading.

In addition to meeting the UTS, glass compositions must be designed to protect the environment and human health by ensuring acceptable leach resistance. The leach test criterion being used to judge the acceptability of HLW glasses fabricated at Savannah River Site (SRS)

and West Valley Nuclear Services (WVNS) — the product consistency test (PCT) — is used as a measure of leach resistance for these glasses. For HLW glasses, the normalized release of B, Na, and Li (r_B, r_{Na}, and r_{Li}, respectively) by PCT must be lower than the corresponding releases from Defense Waste Processing Facilities (DWPF) Environmental Assessment (EA) glass (Jantzen et al., 1993). This criterion, while not required for transportation or disposal, was also applied to the calculated EVB waste glasses to ensure high durability.

Acceptability of the waste form in the WIPP also requires safeguards termination (i.e., reduction to level E safeguards), which requires Pu concentrations below 5 wt% (McCullum, 1996). Additional limits have been imposed on the shipping of TRU waste to ensure criticality safety. This limit translates to 200 fissile gram equivalents in a 208 L drum (55 gal). The practical limitation, however, is based on measurement uncertainty. This limit is 200 g Pu minus two times the measurement uncertainty, typically ~167 g Pu per drum for LANL waste forms. The current vitrification flowsheet specifies a waste loading target of 25% on an oxide weight basis. This translates to an average Pu loading of 0.1 wt% PuO_2 in glass.

Additional restrictions are placed on the frit composition to ensure that the glass can be processed in the melter system developed for the process. The glass development for this waste stream began before the melter technology was determined. Generally, viscosity, electrical conductivity, and liquidus temperature are controlled for melter systems (Bickford et al., 1990). The viscosity is restricted between 2 and 10 Pa·s at melting temperature to ensure smooth bottom drain operation. In addition, the glass viscosity at the processing temperature (η_T) should be maintained above 2 Pa·s to avoid excessive corrosion of the melter construction material, and below 10 or 15 Pa·s to keep processing times reasonable. Electrical conductivity should be strictly controlled at levels specific to the melter design for induction heating or maintained between roughly 10 and 100 S/m at the processing temperature for Joule-heated melters. Currently, LANL plans to use resistance heating rather than induction or Joule. However, LANL may change the melter technology in the future. Liquidus temperature (T_L) is often a processing concern for waste glass melters. The T_L of glass is often maintained below the melting temperature to avoid accumulation of crystals, which can short heating electrodes or clog pour spouts in melters.

Testing was performed on glasses designed before the design of the melter system was complete. The initial assumptions about processing requirements that the glass would meet include: 1) no restriction on electrical conductivity (because the melter was initially assumed to be resistance heated), 2) the processing temperature would be 1100°C, 3) η_{1100} would be between 2 and 10 Pa·s, and 4) no restriction would be placed on T_L. The glass composition experimental region and test matrix described in Steps 3 and 4 were based upon these assumptions. However, refinement of the melter design changed the processing temperature to 1050°C. That change is reflected in the restrictions used for frit composition optimization, described below.

Table II lists the restrictions used for frit development in this study. These restrictions are dependent upon the waste stream, the disposal path, and vitrification technology; and are not generally applicable to every vitrification problem.

Table II. Glass property restrictions

Restriction	Test	Limiting values
Universal treatment standard	TCLP	0.3 Ag, 5 As, 7.6 Ba, 0.19 Cd, 0.86 Cr, 5 Ni, and 0.37 Pb (all mg/L)
Glass durability	PCT	$r_B < 8.5$ and $r_{Na} < 6.6$ g/m^2
Processability	Viscosity	$2 < \eta_{1050} < 10$ Pa·s
Waste loading	-	25 wt% oxide in glass

Glass Composition Experimental Region *(Step 3)*

Preliminary calculations of glass compositions were made using existing glass property databases (Hrma et al. 1994, Bulkley and Vienna 1997, and Vienna et al. 1996). Preliminary calculations narrowed the glass composition region expected for the EVB to that listed in Table III. The EVB glass composition experimental region (GCER) is described by the minimum and maximum columns in Table III. The methods used to select the glass compositions in the GCER for experimental study are described in the following section. In addition to the single component ranges listed in Table III, the GCER was further restricted by constraints that the combined alkalis (Na_2O, K_2O, and Li_2O) be less than 25 wt% of glass, and the calculated glass viscosities range between 2 and 10 Pa·s at 1100°C. The composition ranges for the Hanford HLW CVS and Pu residue studies included in Table III are discussed later.

Table III. Glass composition experimental regions for the EVB, HLW, and Pu residue glass studies

	EVB GCER		CVS HLW[a]		Pu Res Study[b]	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Al_2O_3	0.00	12.00	0.00	15.00	0.00	10.00
B_2O_3	2.00	20.00	5.00	20.00	0.00	12.00
CaO	0.00	12.00	0.00	10.00	0.00	8.00
CeO_2	-	-	-	-	???	???
Cr_2O_3	-	-	-	-	-	-
Fe_2O_3	0.00	12.00	0.50	15.00	-	-
K_2O	0.00	15.00[c]	-	-	0.00	6.00
Li_2O	0.00	10.00[c]	1.00	7.00	0.00	4.50
MgO	0.00	12.00	0.00	8.00	2.00	8.00
Na_2O	0.00	16.00[c]	5.00	20.00	0.00	8.00
NiO	-	-	-	-	-	-
PbO	0.00	5.00[d]	-	-	0.00	10.00
SiO_2	40.00	66.00	41.00	57.00	40.00	55.00
SnO	-	-	-	-	0.00	4.00
TiO_2	-	-	-	-	0.00	5.00
ZrO_2	-	-	0.00	13.00	0.00	5.00
Others	0.10	4.00	1.00	10.00	5.00	6.80[e]

[a] from Hrma, et al. 1994, [b] from Bulkley and Vienna 1996, [c] $K_2O+Li_2O+Na_2O \leq 25$wt%, [d] PbO varies as a part of the others component except for one composition included in the test matrix which is discussed later, [e] Others was not directly varied in this study, but only offset changes in the listed components, - Denotes components in glass (as Others) at low levels that were not systematically varied.

Experimental Matrix Design *(Step 4)*

Table IV lists the test matrix of 36 glasses used to explore the EVB GCER defined in Table III. The 36 glasses were selected in two stages. In the first stage, glasses LANL-A to LANL-U were selected, using a fractional factorial type design. The fraction of the factorial design was chosen based on subject matter knowledge and interest rather than according to statistical methods for fractionating factorial designs. In the second stage, glasses LANL-V to LANL-AK were selected to optimally augment the 21 first-stage glasses, using computer-aided statistical experimental design techniques and software as described in the following paragraph.

The MCCVRT routine of the MIXSOFT software (Piepel 1994) was used to generate the 2269 vertices of the EVB GCER defined in Table III (with the exception that PbO was not included as a varied component). Two additional restrictions were added to the design – the glass viscosity at 1100°C was restricted to 2 to 10 Pa·s and the total alkali was maintained below 25 wt%. The decision was made later to restrict the viscosity (2 to 10 Pa·s) at 1050°C instead of 1100°C. These 2269 vertex glass compositions were appended to the 21 LANL-A to LANL-U compositions to yield a set of candidate points from which the final experimental design of 36 compositions was constructed.

The ACED software (Welch 1987) was used to generate the final 36-composition experimental design. First, the 21 first-stage LANL compositions (LANL-A to LANL-U) were "forced" into the design. Then, the D-optimality criterion and the excursion algorithm of ACED were used to select 15 compositions from the 2269 EVB GCER vertices to optimally augment the 21 existing LANL compositions. The D-optimality criterion involves minimizing $|(X'X)^{-1}|$, where in this case X represents the 36 x 10 matrix of compositions ultimately selected for the experimental design. X' represents the matrix transpose of X, and the superscript -1 indicates the matrix inverse. For this application, D-optimality means that design points are selected to minimize the uncertainty in property-composition coefficients estimated from the resulting property-composition data. Spreading points out as far as possible in the GCER minimizes uncertainty in property-composition relationships. That is why the vertices of the EVB GCER were used as candidate points to augment the 21 first-stage LANL glasses.

The ACED software uses mathematical optimization methods to select design points that minimize $|(X'X)^{-1}|$. The "excursion algorithm" in ACED considers designs of sizes smaller and larger than the desired size (36 points in this case) as one way to avoid suboptimization (i.e., stopping at local minima). ACED also avoids suboptimization by generating designs from different randomly chosen starting points. Ultimately, there were many nearly optimal ways to select 15 vertices from 2269 vertices to augment the 21 first-stage points. One of those options was selected, based on other statistical properties and on a review of glass science. In summary, ACED was used to select a set of 15 vertices spread around the boundary of the GCER. This was done in a way that optimally augments the 21 first-stage LANL glasses, to minimize the uncertainty in estimating property-composition relationships from the measured data.

Table IV. Experimental glass compositions in wt% oxides

Glass	Al_2O_3	B_2O_3	BaO	CaO	CeO_2*	Cr_2O_3	Fe_2O_3	K_2O	Li_2O	MgO	Na_2O	Nd_2O_3	NiO	PbO	SiO_2
LANL-A	5.00	6.00	0.00	6.70	0.19	0.23	1.91	1.66	5.00	7.64	12.27	0.00	0.18	0.02	53.20
LANL-B	0.68	6.00	0.00	6.70	0.19	0.23	1.91	1.66	5.00	7.64	11.92	0.00	0.18	0.02	57.87
LANL-C	0.68	6.00	0.00	6.70	0.19	0.23	1.91	5.00	5.00	7.64	9.76	0.00	0.18	0.02	56.69
LANL-D	5.00	15.00	0.00	6.70	0.19	0.23	1.91	1.66	0.00	7.64	16.53	0.00	0.18	0.02	44.94
LANL-E	5.00	15.00	0.00	6.70	0.19	0.23	1.91	5.00	0.00	7.64	14.38	0.00	0.18	0.02	43.76
LANL-F	5.00	15.00	0.00	6.70	0.19	0.23	1.91	1.66	5.00	7.64	5.38	0.00	0.18	0.02	51.09
LANL-G	0.68	15.00	0.00	6.70	0.19	0.23	1.91	1.66	0.00	7.64	16.18	0.00	0.18	0.02	49.61
LANL-H	0.68	15.00	0.00	6.70	0.19	0.23	1.91	1.66	5.00	7.64	5.03	0.00	0.18	0.02	55.76
LANL-I	5.00	15.00	0.00	12.00	0.19	0.23	1.91	1.66	0.00	7.64	12.13	0.00	0.18	0.02	44.04
LANL-J	5.00	15.00	0.00	6.70	0.19	0.23	1.91	1.66	0.00	12.00	13.93	0.00	0.18	0.02	43.18
LANL-K	5.00	15.00	0.01	10.05	0.28	0.34	2.86	2.50	0.00	11.46	10.29	0.00	0.27	0.02	41.91
LANL-L	5.00	15.00	0.00	6.70	0.19	0.23	5.00	1.66	0.00	7.64	15.04	0.00	0.18	0.02	43.33
LANL-M	5.00	15.00	0.00	6.70	0.19	0.23	1.91	1.66	0.00	7.64	13.48	0.00	0.18	5.00	43.00
LANL-N	5.00	5.00	0.00	6.70	0.19	0.23	1.91	5.00	5.00	7.64	10.88	0.00	0.18	0.02	52.25
LANL-O	5.00	15.00	0.00	6.70	0.19	0.23	1.91	5.00	5.00	7.64	3.23	0.00	0.18	0.02	49.90
LANL-P	0.68	15.00	0.00	12.00	0.19	0.23	1.91	1.66	5.00	7.64	0.78	0.00	0.18	0.02	54.70
LANL-Q	0.68	5.00	0.00	12.00	0.19	0.23	1.91	1.66	5.00	7.64	8.28	0.00	0.18	0.02	57.21
LANL-R	0.68	5.00	0.00	6.70	0.19	0.23	1.91	1.66	5.00	12.00	10.08	0.00	0.18	0.02	56.35
LANL-S	1.02	5.00	0.01	10.05	0.28	0.34	2.86	2.50	5.00	11.46	6.47	0.00	0.27	0.02	54.71
LANL-T	5.00	5.00	0.00	6.70	0.19	0.23	1.91	5.00	5.00	12.00	8.28	0.00	0.18	0.02	50.49
LANL-U	0.68	11.68	0.00	6.70	0.19	0.23	1.91	1.66	5.87	7.64	5.65	0.00	0.18	0.02	57.60
LANL-V‡	0.00	20.00	0.00	0.00	0.00	0.05	12.00	15.00	3.09	0.00	6.91	0.02	0.02	0.00	42.90
LANL-X‡	12.00	20.00	0.01	12.00	0.17	1.89	0.00	0.00	8.23	0.00	0.00	0.91	0.97	0.05	43.77
LANL-Y	0.00	20.00	0.01	12.00	0.17	1.89	12.00	0.00	5.20	0.00	0.00	0.91	0.97	0.05	46.80
LANL-Z	12.00	2.18	0.01	12.00	0.17	1.89	0.00	15.00	10.00	0.00	0.00	0.91	0.97	0.05	44.82
LANL-AA	12.00	2.00	0.01	0.00	0.17	1.89	12.00	0.00	8.76	12.00	9.24	0.91	0.97	0.05	40.00
LANL-AB	12.00	5.36	0.01	0.00	0.17	1.89	0.00	15.00	10.00	12.00	0.00	0.91	0.97	0.05	41.64
LANL-AC	0.00	2.00	0.00	0.00	0.00	0.05	12.00	0.00	9.97	0.00	15.03	0.02	0.02	0.00	60.90
LANL-AD	4.16	2.00	0.01	0.00	0.17	1.89	0.00	0.00	7.84	0.00	16.00	0.91	0.97	0.05	66.00
LANL-AE	12.00	2.00	0.00	12.00	0.00	0.05	12.00	15.00	4.76	0.00	0.00	0.02	0.02	0.00	42.14
LANL-AF	12.00	20.00	0.00	0.00	0.00	0.05	12.00	0.00	4.06	11.84	0.00	0.02	0.02	0.00	40.00
LANL-AG	12.00	20.00	0.00	0.00	0.00	0.05	0.00	0.00	9.99	0.00	0.00	0.02	0.02	0.00	57.91
LANL-AH	0.00	20.00	0.01	0.00	0.17	1.89	0.00	15.00	0.00	0.00	9.68	0.91	0.97	0.05	51.32
LANL-AI	0.00	2.00	0.01	12.00	0.17	1.89	12.00	15.00	0.00	12.00	0.17	0.91	0.97	0.05	42.83
LANL-AJ	12.00	2.00	0.01	12.00	0.17	1.89	12.00	0.00	1.06	0.00	16.00	0.91	0.97	0.05	40.94
LANL-AK	0.00	2.00	0.01	0.00	0.17	1.89	12.00	0.00	8.89	12.00	0.00	0.91	0.97	0.05	61.11

* CeO_2 was added to glasses as a surrogate for PuO_2. ‡ There is no LANL-W composition due to a lettering error. Note: LANL-M is the only composition in the test matrix that varied PbO beyond the negligible levels in the other glasses. Thus, this data point could be highly influential in data analyses.

The scatterplot matrix in Figure 2 shows that the 36-composition test matrix in Table IV covers the EVB GCER reasonably well. The LANL-A to LANL-U glasses have restricted ranges for most of the glass components, compared to the EVB GCER ranges.

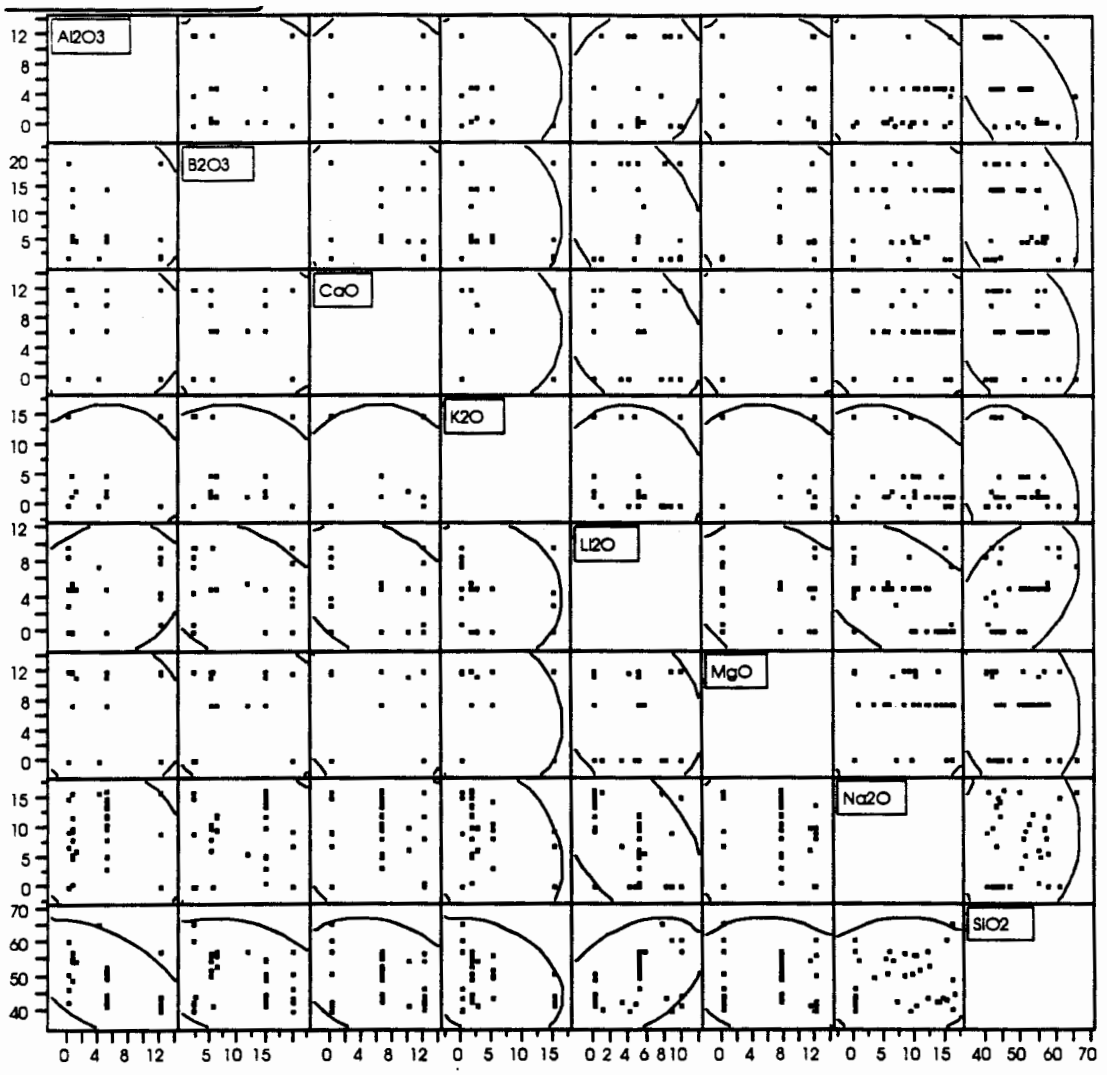

Figure 2. Scatter plot matrix of 36 test glass compositions (lines represent 95% bivariate normal density ellipses), Fe_2O_3 and others were omitted from the plot for ease of viewing

Testing and Glass Property Data *(Step 5)*

Each glass was melted in a Pt-10% Rh crucible with lid for 1 h in 350 g batches, ground in a tungsten carbide mill for 2-8 min, and re-melted for 1 h. The glass was quenched to room temperature on a steel plate. TCLP was performed on quenched glass in acetic acid at pH 4.7 for 18 h at 25°C with a glass surface area to solution volume ratio (S) of 45 m^{-1}. The resulting solutions were analyzed using inductively coupled plasma atomic emission spectroscopy (ICP/AES). TCLP releases were normalized to mass of element released per mass of element in glass (in g/g). Glass viscosity vs. temperature profiles were measured between approximately 2 and 50 Pa·s with a calibrated spindle viscometer, according to procedures reported previously (Hrma, et al. 1994). The PCT was performed according to the ASTM 1285 standard test procedure (ASTM 1995) in de-ionized water for 7 days at 90°C. PCT data were normalized to

g/m^2 release, according to standard Materials Characterization Center (MCC) procedures (Hrma, et al. 1994).

Toxicity Characteristic Leach Procedure

TCLP data are reported as absolute releases (mg/L) for the restricted metals Cr, Ni, and Ba in Table V. Two other restricted metals (Pb and Cd) were present in the Table IV glasses; however, their releases were below the detection limit with three exceptions (two for Cd and one for Pb). Both As and Se were reported in the waste in very low quantities, but were not used in glass fabrication. The UTS and RCRA limits for restricted metal release from a glass waste form are also listed in Table V for comparison. The TCLP Ba releases for tested glasses range from
0.01 mg/L to 0.14 mg/L, all well below the UTS and RCRA limits. The TCLP Cd releases for tested glasses range from ≤0.02 mg/L to 0.04 mg/L, all well below the UTS and RCRA limits. The TCLP Cr releases for tested glasses range from well below the UTS limits (≤0.06 mg/L) to well above them (3.10 mg/L), while all were below the RCRA limits. The TCLP Ni releases for tested glasses range from well below the UTS limits (≤ 0.06 mg/L) to well above them (8.25 mg/L). RCRA doesn't restrict Ni release in a glass waste form. The TCLP Pb releases for tested glasses range from well below both the UTS and RCRA limits (≤0.30 mg/L) to well above them (26.95 mg/L).

Table V. TCLP results for LANL EVB glasses (mg/L)

Glass	B	Ba	Cd	Cr	Ni	Pb	Glass	B	Ba	Cd	Cr	Ni	Pb
LANL-A	13.13	0.03	0.04	0.12	1.03	(0.30)	LANL-S	1.36	0.02	(0.02)	0.08	0.20	(0.30)
LANL-B	1.45	0.01	(0.02)	(0.06)	0.13	(0.30)	LANL-T	18.89	0.06	0.04	0.32	1.81	(0.30)
LANL-C	3.29	0.02	(0.02)	(0.06)	0.20	(0.30)	LANL-U	1.37	0.01	(0.02)	(0.06)	0.07	(0.30)
LANL-D	115.77	0.08	(0.02)	0.09	3.10	(0.30)	LANL-V	147.56	-	-	(0.06)	0.40	(0.24)
LANL-E	108.33	0.07	(0.02)	0.13	2.98	(0.30)	LANL-X	2.97	0.02	-	0.06	0.38	(0.30)
LANL-F	4.89	0.01	(0.02)	(0.06)	0.10	(0.30)	LANL-Y	16.97	0.06	-	0.12	2.24	(0.24)
LANL-G	117.61	0.11	(0.02)	(0.06)	3.26	(0.30)	LANL-Z	5.16	0.07	-	2.49	3.49	(0.30)
LANL-H	5.24	0.02	(0.02)	(0.06)	0.12	(0.30)	LANL-AA	0.72	0.02	-	0.09	0.31	(0.24)
LANL-I	98.61	0.09	(0.02)	(0.06)	2.61	(0.30)	LANL-AB	12.77	0.03	-	2.13	4.27	(0.30)
LANL-J	93.54	0.09	(0.02)	0.09	2.64	(0.30)	LANL-AC	0.12	-	-	(0.06)	(0.06)	(0.24)
LANL-K	66.38	0.06	(0.02)	0.06	2.82	(0.30)	LANL-AD	0.08	0.01	-	(0.06)	0.07	(0.30)
LANL-L	53.06	0.05	(0.02)	(0.06)	1.52	(0.30)	LANL-AE	0.13	-	-	(0.06)	(0.06)	(0.24)
LANL-M	71.21	0.07	(0.02)	(0.06)	2.15	26.95	LANL-AF	0.91	-	-	(0.06)	(0.06)	(0.24)
LANL-N	19.54	0.07	0.02	0.27	1.79	(0.30)	LANL-AG	0.53	-	-	(0.06)	(0.06)	(0.30)
LANL-O	17.78	0.03	(0.02)	0.06	0.59	(0.30)	LANL-AH	80.92	0.14	-	3.10	8.25	(0.30)
LANL-P	19.70	0.04	(0.02)	0.06	0.66	(0.30)	LANL-AI	2.35	0.05	-	0.54	1.58	(0.30)
LANL-Q	1.07	0.01	(0.02)	(0.06)	0.12	(0.30)	LANL-AJ	0.27	0.02	-	0.13	0.08	(0.24)
LANL-R	2.89	0.02	(0.02)	0.07	0.30	(0.30)	LANL-AK	0.13	0.01	-	(0.06)	0.08	(0.24)
Blank-1	(0.03)	0.01	0.03	(0.06)	0.07	(0.30)	Blank-3	0.05	(0.01)	(0.02)	(0.06)	(0.06)	(0.30)
Blank-2	(0.03)	(0.01)	(0.02)	(0.06)	(0.06)	(0.30)	Blank-4	0.09	0.02	(0.02)	(0.06)	(0.06)	(0.30)
UTS limit	N/A	7.60	0.19	0.86	5.00	0.97	RCRA limit	N/A	100.00	1.00	5.00	N/A	5.00

Parenthetical values signify the detection limit, below which the value lies. "-" indicates that the component was not present in the glass. Four "Blank" samples were measured and included for information in the table. No attempt was made to correct for blank sample measured values.

Glass leach resistance under TCLP conditions can be estimated by the negative logarithm of the fractional release, -ln[f_i]. Equation (1) illustrates the conversion between TCLP release values and f_i:

$$f_i = \frac{C_i}{g_i m_i S}, \tag{1}$$

where C_i is the solution concentration of the ith element (mg/L), g_i is the mass fraction of the ith oxide in glass, m_i is the mass fraction of the ith element in the oxide, and S is the glass surface area to solution volume ratio. Note in Eq. (1) that the C_i values are not blank-corrected. Four blank solutions were submitted for chemical analysis along with TCLP solutions. However, the blank results were almost always below detection limits, so that blank-correcting the data would have introduced biases or increased variance into the raw TCLP release data. Thus, blank corrections were not performed. Table VI lists the -ln[f_i] values, where i denotes the element among B, Ba, Cd, Cr, Ni, and Pb.

Table VI. Negative logarithm of fractional release, -ln[f_i]

Glass	B	Ba	Cd	Cr	Ni	Pb	Glass	B	Ba	Cd	Cr	Ni	Pb
LANL-A	4.26	3.95	3.12	6.46	4.22		LANL-S	6.34	5.05		7.22	6.27	
LANL-B	6.46	4.83			6.32		LANL-T	3.72	3.41	3.11	5.47	3.66	
LANL-C	5.65	4.63			5.87		LANL-U	7.19	4.96			6.85	
LANL-D	3.00	3.10		6.73	3.12		LANL-V	3.05				3.16	
LANL-E	3.07	3.19		6.38	3.16		LANL-X	6.95	5.72		9.27	6.92	
LANL-F	6.17	5.05			6.58		LANL-Y	5.21	4.39		8.59	5.14	
LANL-G	2.99	2.83			3.06		LANL-Z	4.18	4.27		5.56	4.69	
LANL-H	6.10	4.60			6.39		LANL-AA	6.06	5.41		8.92	7.10	
LANL-I	3.16	2.97			3.29		LANL-AB	4.18	5.05		5.72	4.49	
LANL-J	3.21	3.04		6.72	3.28		LANL-AC	7.85					
LANL-K	3.56	3.78		7.50	3.62		LANL-AD	8.29	6.20			8.61	
LANL-L	3.78	3.58			3.83		LANL-AE	7.79					
LANL-M	3.49	3.19			3.48	4.46	LANL-AF	8.14					
LANL-N	3.68	3.26	3.72	5.67	3.66		LANL-AG	8.69					
LANL-O	4.88	4.01		7.14	4.77		LANL-AH	3.65	3.58		5.34	3.83	
LANL-P	4.77	3.86		7.14	4.66		LANL-AI	4.88	4.53		7.08	5.49	
LANL-Q	6.59	4.98			6.39		LANL-AJ	7.04	5.67		8.49	8.48	
LANL-R	5.59	4.32		6.97	5.47		LANL-AK	7.76	6.01			8.52	

Note: Missing values are those with concentrations below the detection limits or glasses without the component being measured.

Salt separation

The chromate separation shown in Figure 3 was identified in samples of compositions LANL-X, -Y, -Z, -AA, -AB, -AD, and -AK from this study, and in SRC-Mg-2 and -Mg-3 in Bulkley and Vienna (1996). All seven of the LANL glasses that formed the chromate phase

contained the highest Cr_2O_3 concentration tested, 1.89 wt%. Ten glasses were tested with 1.89 wt% Cr_2O_3 including those listed above plus LANL-AH, -AI, and -AJ. The Li_2O concentration of the three glasses with 1.89 wt% Cr_2O_3 that didn't form chromate phase were 0.00 wt%, 0.00 wt%, and 1.06 wt%, respectively. The Li_2O concentration of the glasses which did form chromate was much higher, ranging from 5.20 wt% to 10.00 wt%. No other compositional trends were found. Chromate separation was shown to form in highly basic waste glass melts (Hlavac and Maruskova 1995, Li et al. 1997, and Darab et al. 1995). The basicity of all glasses was calculated according to the methods described by Volf (1988). No correlation between calculated glass basicity and chromate formation was seen for the high-Cr_2O_3 LANL glasses.

Chromate forms at low-temperatures in low viscosity, alkaline salt melts, while the glass batch materials begin to react. The phase then floats to the top of the higher density glass phase. Because the test glass melts in this study were formed from mixtures of metal oxides and carbonates, the formation of chromate in a glass melter with prefused glass frit and nitrate waste feed cannot be predicted from these data. Nearly full scale testing with waste simulant and prefused frit is recommended to test the possibility of chromate formation in the production plant.

To help avoid the separation of chromate in glass, high-Cr wastes can be blended to reduce Cr_2O_3 concentration, the melt can be reduced, or the Cr can be precipitated from the melt in the form of iron-nickel-chrome spinels. Spinel formation is a preferred method for accommodating high concentrations of Cr since: 1) the spinel rapidly crystallizes from glass below the liquidus temperature (T_L) (Reynolds and Hrma 1997), 2) it's known to have little effect on glass durability (Kim, et al. 1995), 3) its formation is easily induced and predicted (Mika et al. 1997 and Hrma et al. 1998), and 4) it has little effect on in-can glass processing. To increase the T_L of spinel in waste glasses while maintaining adequate properties, Al_2O_3 should be added to the frit and Li_2O should be used as a flux rather than Na_2O (Vienna et al. 1997).

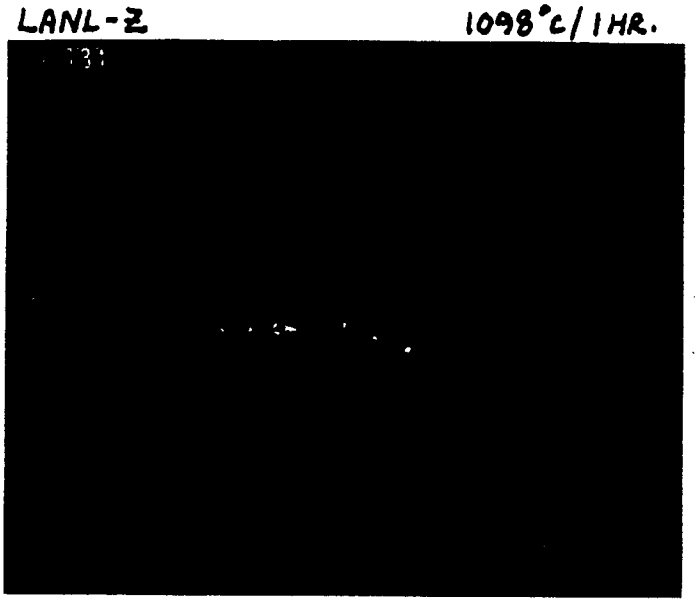

PHOTO: INSIDE OF CRUCIBLE AFTER 1ST MELT (GLASS ON BOTTOM WITH YELLOW BAND (CHROMATE) ABOVE MELT)

Figure 3. Chromate phase separation in LANL-Z glass

Property-Composition Relationships *(Step 6)*

Three data sets were used to develop or make predictions with property-composition relationships. The first data set is for the glasses in Table IV, which were designed to cover the composition region expected from vitrifying EVB wastes at LANL. The second data set is for glasses designed in a one-component-at-a-time change study based on a similar Pu-bearing material (Bulkley and Vienna 1997). The third data set is from glasses developed to cover the composition region expected from Hanford HLW glasses (Hrma et al. 1994). The first and second data sets were used to develop TCLP-composition relationships for LANL EVB glasses. The second and third data sets were used to develop viscosity-composition relationships for LANL EVB glasses. The third data set was used to develop electrical conductivity-composition relationships, as well as PCT release-composition relationships for LANL EVB glasses. A limited number of glasses from the first data set were used to validate the viscosity and PCT predictions based on the third data set.

Glass property data were interpolated, and in some cases extrapolated, to glass compositions of interest using property-composition relationships estimated from measured data. To explain this, consider the property-composition relationship:

$$P = \sum_{i=1}^{n} a_i g_i , \tag{2}$$

where P is a property or a transformed property (e.g., $-\ln[f_B]$), n is the number of major glass components, a_i is the ith component's partial specific property, and g_i is the ith component's mass fraction in the glass. Henceforth Eq. (2) is referred to as a first-order mixture (FOM) model.

While the "linear blending" form of Eq. (2) is widely known and used, it is not ideal for interpretation purposes. For constrained glass composition regions, the a_i coefficients obtained by fitting Eq. (2) to data are extrapolated predictions of property values for pure components. Hence, the a_i coefficients provide little basis for interpretation if they correspond to significant extrapolations. Eq. (2) can be rewritten in the mathematically equivalent form:

$$P = P_0 + \sum_{i=1}^{n} b_i s_i (1 - s_i) g_i \,, \tag{3a}$$

where,

$$\sum_{i=1}^{n} b_i s_i (1 - s_i) = 0 \,. \tag{3b}$$

In these equations, s_i is the mass fraction of glass component i in a particular glass composition $\mathbf{s}=(s_1, s_2, \ldots, s_n)$ of interest (usually somewhere in the center of the glass composition space of interest). P_0 is the predicted value of P at $\mathbf{s}$, and is calculated via:

$$P_0 = \sum_{i=1}^{n} a_i s_i \,. \tag{4a}$$

The coefficient b_i is the slope of the relationship (2) at the composition $\mathbf{s}$, along the direction of adding/subtracting the ith component to/from $\mathbf{s}$. The b_i coefficients are obtained from the a_i values via:

$$b_i = \frac{a_i - P_0}{1 - s_i} \,. \tag{4b}$$

Hence the b_i can usefully be interpreted as the slopes of the property response surface corresponding to additions/subtractions of the ith component to/from a "baseline" glass composition, $\mathbf{s}$. The equality constraint on the b_i in Eq. (3b) is needed to avoid over-parameterization resulting from converting Eq. (2) having n parameters ($a_1, a_2, \ldots, a_n$) to Eq. (3a) having n+1 parameters ($P_0, b_1, b_2, \ldots, b_n$).

Estimates of glass leach resistance under the TCLP conditions are given by the $-\ln[f_i]$ values in Table VI. Insufficient data exists to develop glass composition relationships to the release of each of the restricted metals individually. In addition, many of the restricted metals participate in secondary reactions, which further complicates prediction of their releases under TCLP conditions. To predict the TCLP release of restricted elements, the $-\ln[f_i]$ value for boron, $-\ln[f_B]$, is fitted to the compositions of the glasses according to Eq. (2). Because boron doesn't participate in ion-exchange processes and is seldom involved in secondary reactions in the leached solution, it is a good indicator of glass dissolution. The data from the Pu residue study of Bulkley and Vienna (1997) and the LANL EVB data were separately fitted to FOM models. Table VII shows the component coefficients (a_i values) for $-\ln[f_B]$ fitted to both data sets, along with the slopes of the component change vs. $-\ln[f_B]$ response taken at two glass compositions – the centroid of the LANL glasses and the baseline of the Pu residue study. The differences in apparent component effects (slopes) between the two data sets suggest that the data sets should not be combined without adding terms to account for the non-linear response of $-\ln[f_B]$ to change in composition.

The R^2 values from the FOM models in Table VI are 0.827 and 0.865, meaning that the models account for 82.7% and 86.5% of the variation in the measured $-\ln[f_i]$ values from the LANL EVB and Pu residue data sets, respectively. Although these are reasonably good R^2 values, they indicate that there likely exist non-linear blending effects of the glass components on TCLP releases. Adding four pure-quadratic terms (g_i^2) to the LANL EVB FOM model increased the R^2 from 0.827 to 0.931. Adding five pure-quadratic blending terms to the Pu residue FOM model increased the R^2 from 0.865 to 0.994. However, FOM models without second-order terms are better able to predict the properties of glasses not strictly in the composition range covered by model data.

Figure 4 compares the predicted TCLP B release values with the measured TCLP release values for restricted elements. The 45° line at "y=x" in Figure 4 represents the ideal in which predicted values exactly equal measured values. Data points below the 45° line represent conservative predictions (the predicted values are higher than the measured values), while data points above the 45° line represent under predictions. An additional 45° line at "y=x+10" in Figure 4 shows and order of magnitude under-prediction. For Cr, the most restrictive component, the predictions are conservative in every case. Likewise, the prediction for Pb release are always conservative. Predictions for Ba and Cd with measured releases below 0.1 mg/L tend to be non-conservative. Predictions for Ni release are scattered around the 45° line, indicating roughly accurate predictions. Those Ni releases calculated to be below the UTS Limit of 5 mg/L are below 5 mg/L. Conservative predictions might have been expected given that TCLP B releases are expected to bound releases of the restricted elements. However, non-conservatism is seen for Ba and Cd, both components are known to participate in ion-exchange processes during glass leaching.

Based upon these model results, the TCLP release limits used for glass development will be altered to ensure conservative prediction. The limits for Cr, Ni, and Pb releases used in glass formulation will be the UTS limits (0.86 mg/L, 5 mg/L, and 5 mg/L, respectively). The formulation limits on TCLP releases of all other metals will be one order-of-magnitude below the UTS limit (0.03 mg/L Ag, 0.5 mg/L As, 0.76 mg/L Ba, and 0.019 mg/L Cd).

Table VII. First-order mixture (FOM) and slope models for $-\ln[f_B]$[a] fitted to the LANL and Pu residue data sets

	36 LANL EVB Glasses			32 Pu residue Glasses [b]		
Component	FOM	Slope FOM LANL Cent.	Slope FOM Pu res Baseline	FOM	Slope FOM LANL Cent.	Slope FOM Pu res Baseline
Intercept [c]	N/A	5.25	3.72	N/A	5.24	7.93
Al_2O_3	21.10	16.83	18.28	12.78	8.01	5.11
B_2O_3	-9.23	-15.91	-13.79	-12.19	-19.15	-21.40
CaO	-7.92	-13.85	-12.24	-3.06	-8.73	-11.56
CeO_2				16.21	10.99	8.67
Fe_2O_3	11.55	6.65	7.82			
K_2O	-15.58	-22.69	-19.91	-11.67	-18.43	-20.21
Li_2O	-23.13	-29.98	-27.97	-6.28	-12.17	-14.80
MgO	-11.04	-17.19	-15.07	-5.56	-11.40	-13.77
Na_2O	-20.09	-27.00	-26.46	1.71	-3.77	-6.92
PbO				4.90	-0.34	-3.06
SiO_2	19.00	26.37	27.77	12.85	14.60	8.95
SnO				12.66	7.41	4.72
TiO_2				13.10	7.86	5.22
ZrO_2				16.14	10.90	8.46
LANL Others	-6.54	-12.03	-12.85[d]	N/A	N/A	N/A
Pu res Others	N/A	N/A	N/A	14.51	9.98	7.35
R^2	0.827	0.827	0.827	0.865	0.865	0.865
R^2(adj)	0.768	0.768	0.768	0.768	0.768	0.768

(a) TCLP B release was selected as representative or conservative of other normalized releases, including the restricted metals Ba, Cd, Cr, Ni, and Pb that were released in detectable amounts from glasses in the LANL EVB test matrix.

(b) The four glasses in this data set involving one-at-a-time variations in Gd_2O_3 were not used because TCLP was not present in the available database. Apparently, these data are available, and the results should be redone to account for the effect on TCLP of Gd_2O_3 (which is present in the 32 Pu residue glasses used to develop these models).

(c) The intercept is the predicted value of $-\ln[f_B]$ at the: (i) centroid of the LANL glass composition experimental region (obtained by averaging the 2269 extreme vertices of the region), or (ii) the baseline composition of the Pu residue study.

(d) Based on an extrapolation outside the component range for data used to develop the empirical model.

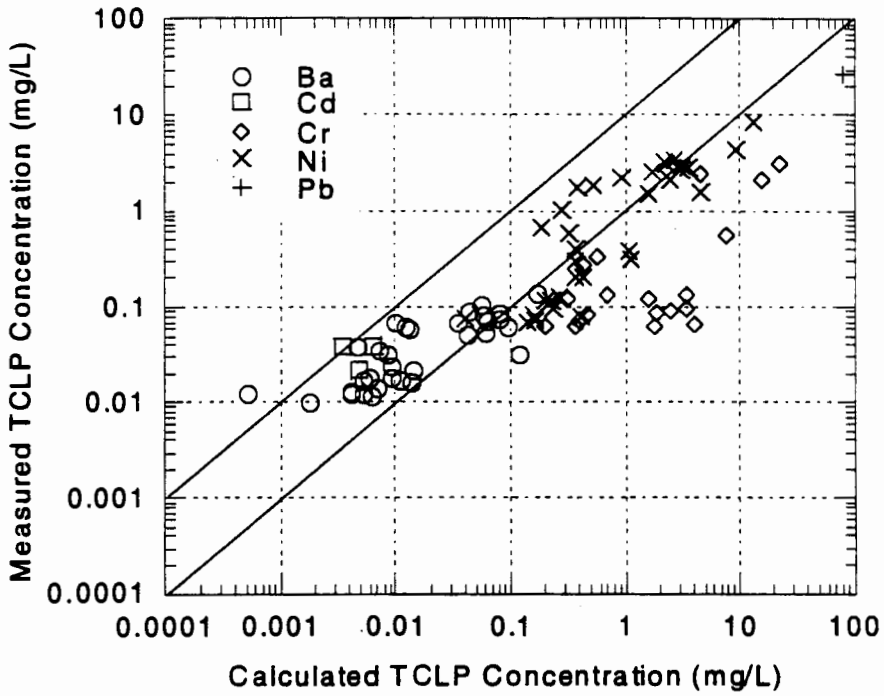

Figure 4. Measured and calculated TCLP releases of Ba, Cd, Cr, Ni, and Pb

The final a_i coefficient values for viscosity, electrical conductivity, TCLP, and PCT are shown in Table VIII. These coefficients were used to calculate the glass property values for proposed EVB glasses to optimize the frit composition, as described in the next section.

Table VIII. FOM model coefficient (partial specific property) values used in glass composition development

Property	Viscosity		Electrical Conductivity		TCLP	PCT	
Model*	A_η	B_η	A_ε	B_ε	$-\ln[f_B]$	$\ln(r_{Na})$	$\ln(r_B)$
Al_2O_3	-4.089	21186.0	7.140	-8227.2	21.1	-25.429	-26.103
B_2O_3	-13.659	10868.0	12.820	-15135.0	-9.23	9.405	10.530
CaO	-22.750	21522.0	14.410	-18769.0	-7.92	-1.957	-8.953
Fe_2O_3	-6.404	8774.0	9.940	-10608.0	11.55	-4.095	-2.214
K_2O	-1.780	0.0	5.318	2616.1	-15.58	-1.531	3.963
Li_2O	-4.514	-42288.0	7.470	22484.0	-23.13	19.064	18.668
MgO	-21.105	25767.0	10.390	-13414.0	-11.04	11.823	10.924
Na_2O	-9.604	-1217.1	6.050	7089.5	-20.09	19.401	15.286
SiO_2	-11.084	28539.0	8.120	-10283.0	19	-4.412	-3.452
Others	-17.017	23027.0	18.110	-20653.0	-6.54	-0.665	1.667
Data sets	CVS	CVS	CVS	CVS	LANL	CVS	CVS
R^2	0.97	0.97	0.96	0.96	0.83	0.85	0.78
Adj R^2	0.97	0.97	0.96	0.96	0.77	0.83	0.75

*For viscosity and electrical conductivity, Arrhenius coefficients are used, for example $\ln[\eta]=A_\eta+B_\eta/T$

Model Validation (*Step 7*)

Validation glasses were used to estimate the accuracy of the glass property predictions used for frit optimization. Validation glasses are glasses that were not used to fit the predictive property-composition relationships. The validation glasses were fabricated, and their properties were measured and compared to the predicted values. These results are reported, by property, in this section.

Specifically, two glasses were selected for validating the viscosity and TCLP property-composition relationships. Table IX lists the compositions of the two glasses, along with their predicted and measured properties. The first of these glasses, LANL-AL, is outside the composition region covered by the 163 glasses of this study. However, it is within the GCER. This glass is thus an extreme composition, for purposes of validation. The second validation glass tested, LANL-AM, is the mean glass composition for the 163 glasses of this study. Both glasses formed spinel at the melting temperature. Viscosity and PCT release were measured for several additional glasses and electrical conductivity was measured for one additional glass. These glasses and validation results are discussed below.

Table IX. Composition and properties for two validation glasses, LANL-AL and -AM

Glass Composition			Glass Properties		
	AL	AM	**LANL-AL**	Calc	Meas
Al_2O_3	8.00	5.47	A_η	-11.3	-10.33
BaO	0.00	0.00	B_η (K)	18,242	16,961
B_2O_3	4.60	5.00	η_{1050} (Pa·s)	12.6	12.0
CaO	6.40	5.82	TCLP -ln[f_B]	6.37	7.92
CdO	-	0.00	TCLP C_{Cr} (mg/l)	0.47	<0.06
CeO_2	0.10	-	TCLP C_{Ni} (mg/l)	0.27	0.08
Cr_2O_3	0.80	0.67	PCT r_{Na} (g/m^2)	*	*
Fe_2O_3	3.60	2.83	PCT r_B (g/m^2)	*	*
HfO_2	-	0.09	**LANL-AM**		
K_2O	4.40	3.55	A_η	-11.6	-11.81
La_2O_3	-	0.01	B_η (K)	18,054	18,627
Li_2O	5.90	7.00	η_{1050} (Pa·s)	8.0	9.7
MgO	8.50	10.02	TCLP -ln[f_B]	5.92	5.44
Na_2O	6.70	6.44	TCLP C_{Cr} (mg/l)	0.62	<0.06
NiO	0.40	0.34	TCLP C_{Ni} (mg/l)	0.36	0.55
PbO	-	0.02	PCT r_{Na} (g/m^2)	1.26	1.78
SiO_2	50.60	52.67	PCT r_B (g/m^2)	1.30	1.70

*PCT values were not measured for LANL-AL

Toxicity Characteristic Leach Procedure data

The TCLP Cr and Ni releases of LANL-AL and LANL-AM are compared to predicted values in Table IX. As concluded in Step 6, the Cr releases are conservatively predicted. The Ni releases, predicted to be below the UTS limits, are below the UTS limits and are both close to the calculated values. No other data has been taken for TCLP model validation.

Viscosity data

For Hanford HLW glass data (Hrma et al. 1994), the viscosity/temperature relationship was shown to be adequately represented by an Arrhenius equation with parameters expressed as first-order functions of composition. To formulate EVB glass compositions, viscosity at 1050°C was predicted using the coefficients given in Table VIII. These coefficients are from the Hanford HLW glass composition variation study (CVS), with the addition of a K_2O coefficient based upon the Pu residue study data (see Table III). Five data points, chosen to be at extremes in the EVB glass composition space, were tested to confirm and validate the viscosity predictive model. Table X lists the predicted and measured viscosity results for LANL-F, -H, -Q, -R, and -U, in addition to the two previously discussed validation glasses (LANL-AL and -AM). The calculated values are within 10% of the measured values, with the exception of LANL-AM, which has a calculated value 16% below the measured value. This is an excellent agreement, considering that the data used for fitting was based on glasses with higher melting temperatures. The increased measured viscosity (over the calculated value) for LANL-AL and -AM was likely caused by the spinel that formed in the glass at temperatures above 1050°C. In summary, the viscosity model in Table VIII appears to adequately represent the relationship between viscosity at 1050°C and glass composition over the LANL EVB GCER. Hence, glasses made with frit optimized using these models should have viscosity at 1050°C values within or close to the desired 2 to 10 Pa·s range.

Table X. Calculated and measured glass viscosity values for selected glasses

	Calculated			Measured		
	A_η	B_η (K)	η_{1050} (Pa·s)	A_η	B_η (K)	η_{1050} (Pa·s)
LANL-F	-12.05	18,810	8.7	-11.11	17,671	9.5
LANL-H	-12.36	19,232	8.8	-11.51	17,987	8.1
LANL-Q	-12.67	19,662	8.9	-11.25	17,807	9.1
LANL-R	-12.46	19,375	8.9	-11.21	17,631	8.3
LANL-U	-12.21	19,023	8.8	-11.51	17,987	8.1
LANL-AL	-11.25	18,242	12.6	-10.33	16,961	12.0
LANL-AM	-11.57	18,054	8.0	-11.81	18,627	9.7

Product consistency test data

Several glasses were tested for PCT to validate the FOM model in Table VIII. The results of these tests are listed in Table XI, and are compared to predicted values in Figure 5. The values

predicted to be below 3 g/m^2 were closely predicted. Glasses with PCT releases calculated to be above 3 g/m^2 were not well predicted, showing high scatter in Figure 6. There was as much as 6 g/m^2 difference between predicted and measured values (LANL-B). The poor prediction performance for larger PCT releases is expected since the data used to generate the model was based on lower release glasses (Hrma et al., 1994). Except for one validation glass, larger PCT releases are under predicted by the PCT-composition relationship in Table VIII. Under-predicting larger PCT releases means that some glass compositions with PCT releases larger than the limits specified in Table II may be allowed during the glass optimization in Step 8.

A margin of error of 3× and 2× for r_B and r_{Na}, respectively will ensure that glasses with predicted releases below the stated limit will actually have releases below that limit. For the purposes of glass optimization (Step 8), release limit of 2.83 g/m^2 and 3.3 g/m^2 will be used for r_B and r_{Na}, respectively.

Table XI. Calculated and measured 7-day PCT results for selected glasses

Glass	r_B (g/m^2)		r_{Na} (g/m^2)	
	Calc	Meas	Calc	Meas
LANL-B	4.6	11.9	5.9	8.6
LANL-C	3.7	10.6	3.9	8.1
LANL-F	1.9	0.8	1.7	1.4
LANL-H	4.3	9.9	3.9	7.8
LANL-N	1.6	0.6	1.8	0.7
LANL-O	1.5	1.1	1.1	1.3
LANL-P	1.3	1.3	1.6	3.1
LANL-Q	1.4	0.6	2.4	1.2
LANL-R	5.0	6.4	6.7	4.8
LANL-S	1.8	2.0	2.7	1.9
LANL-T	1.7	1.4	1.9	1.5
LANL-AM	1.3	1.7	1.3	1.8

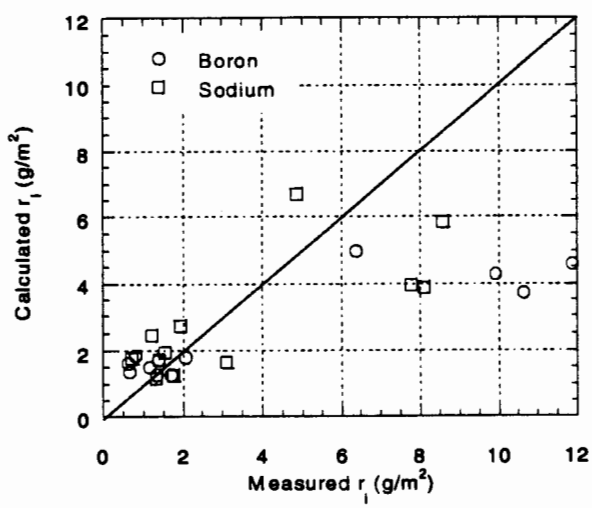

Figure 5. Comparison of calculated and measured PCT data for validation glasses

Electrical conductivity data

For Hanford HLW glass data (Hrma et al. 1994), the electrical conductivity-temperature relationship was shown to be adequately represented by an Arrhenius equation with parameters expressed as first-order functions of composition. To formulate EVB frit compositions, electrical conductivity at 1100°C was predicted using the coefficients in Table VIII (from the Hanford HLW CVS, Hrma et al. 1994). No restrictions were placed on electrical conductivity (see Table II), so predictions were only for general consideration in selecting a frit composition.

Because the electrical conductivity-composition relationship was not used to restrict and formulate the EVB frit and glass compositions, only one glass was used to validate the relationship. The value predicted for LANL-U glass (18.00 S/m) is close to the measured value (22.36 S/m). Since the electrical conductivity is easily adjusted and predicted in waste glasses, and is not crucial to the success of an in-can melting operation, no further measurements were performed.

Frit Optimization *(Step 8)*

An iterative solution routine was used to optimize the frit composition for the vitrification of all 163 waste compositions at a fixed waste loading (25 wt%) with the maximum number of glasses meeting the criteria listed in Table II. For this step, each of the waste compositions was blended (via calculation) with the same concentration of the same frit. Then the resultant glass composition was substituted into property-composition relationships, using the property-composition coefficients in Table VIII to predict property values.

Ideally, the uncertainties in the property-composition relationships should be accounted for in developing frit/glass compositions. Accounting for such uncertainties would increase the probability of frit and glass compositions having acceptable property values. However, the limited funding for this work did not permit accounting for uncertainties in property-composition relationships. To ensure that glasses predicted to meet the property restrictions in Table II, safety margins were added to the "predicted property values" as discussed in Step 7. Table XII shows the limits used for predicted property values used for glass optimization.

Table XII. Restrictions used for glass optimization

Restriction	Property Limit*	Predicted Value Limit
TCLP [Ag]	0.3 mg/L	0.03 mg/L
TCLP [As]	5 mg/L	0.5 mg/L
TCLP [Ba]	7.6 mg/L	0.76 mg/L
TCLP [Cd]	0.19 mg/L	0.019 mg/L
TCLP [Cr]	0.86 mg/L	0.86 mg/L
TCLP [Ni]	5 mg/L	5 mg/L
TCLP [Pb]	0.37 mg/L	0.37 mg/L
PCT r_B	8.5 g/m^2	2.83 g/m^2
TCLP r_{Na}	6.6 g/m^2	3.3 g/m^2
viscosity at 1050°C	$2 < \eta < 10$ Pa·s	$2 < \eta < 10$ Pa·s

* Value from Table II.

The frit composition was altered using a constrained non-linear optimization routine, to maintain the properties of a maximum number of glasses within the acceptable ranges specified in Table II. The resulting frit composition is: 70.26 wt% SiO_2, 8.00 wt% B_2O_3, 5.66 wt% Na_2O, 10.08 wt% Li_2O, and 6.00 wt% Al_2O_3. The ranges of glass compositions for this frit mixed with 25% of each of the 163 waste compositions are given in Table XIII.

Table XIII. Summary of glass compositions with optimized frit in wt%

	Mean	Median	StDev	Min	Max
Ag_2O	0.000	0.000	0.000	0.000	0.001
Al_2O_3	5.335	5.155	1.063	4.500	15.899
Am_2O_3	0.008	0.006	0.006	0.000	0.032
As_2O_3	0.001	0.001	0.002	0.000	0.018
B_2O_3	6.000	6.000	0.000	6.000	6.000
BaO	0.003	0.002	0.004	0.000	0.031
BeO	0.046	0.020	0.072	0.000	0.351
CaO	5.820	5.924	1.882	0.000	15.681
CdO	0.001	0.000	0.003	0.000	0.030
Cr_2O_3	0.673	0.559	0.392	0.079	2.677
Fe_2O_3	2.829	2.378	1.617	0.000	10.311
K_2O	3.552	3.227	2.036	0.000	11.106
Li_2O	7.560	7.560	0.000	7.560	7.560
MgO	10.017	9.777	3.275	0.000	23.142
Na_2O	4.993	4.522	1.770	4.260	19.016
NiO	0.340	0.275	0.212	0.007	1.602
PbO	0.024	0.019	0.021	0.002	0.128
PuO_2	0.094	0.058	0.095	0.000	0.631
SiO_2	52.695	52.695	0.000	52.695	52.695
TlO_x	0.004	0.003	0.007	0.000	0.063
U_3O_8	0.004	0.003	0.004	0.000	0.026

Several glasses (37) that fall outside of the acceptable property restrictions defined in Table II, or that are outside of the GCER, are listed in Table XIV. The two glasses with predicted viscosities higher than 15 Pa·s should not be processed without further testing. The nine glasses with r_{Na} and/or r_B above the specified upper limit values correspond to compositions outside the GCER or have higher than acceptable TCLP releases. Of the 37 glasses in Table XIV, 29 (78.4%) are outside the GCER due to high MgO, 21 of which would be inside the GCER if the MgO limit were increased from 12 to 15 wt%. Glasses with compositions outside the GCER have not been tested and may not melt properly, may not form durable glasses, and/or may not have adequate properties. For these extreme waste compositions, we recommend one of four options:

1) use blended wastes to adjust the chemistry,
2) vitrify the waste at a lower WL,
3) test glass compositions before processing to increase the acceptable region, or
4) treat the waste using an alternative system.

Table XIV. Summary of glasses falling outside of property restrictions or GCER

Set	User Sample ID	Comments	Set	User Sample ID	Comments
HD	2EVDIST15BF1	15.7 wt% CaO	DS	EVDS082696A1	12.3 wt% MgO
HD	EVDIS122195B1	12.7 wt% MgO	DS	EVDS091396A1	13.5 wt% MgO
HD	EVDIS091096B1	12.9 wt% MgO	DS	EVDS091396A2	12.6 wt% MgO
HD	EVDIS091796B1	12.2 wt% MgO	DS	EVDS092596A1	13.5 wt% MgO
HD	EVDIS100496B1	13.0 wt% MgO	DS	EVDS092596A2	13.9 wt% MgO
HD	EVDIS100996B1	12.9 wt% MgO	DS	EVDS100496A1	15.1 wt% MgO
HD	EVDIS101796B2	T_{Cd}=0.032 mg/L	DS	EVDS100496A2	14.1 wt% MgO
HD	EVDIS102996B1	13.5 wt% MgO	DS	EVDS101096A2	13.8 wt% MgO
HD	EVDIS031197B1	20.1 wt% MgO, r_B=5.23 g/m^2, r_{Na}=5.15 g/m^2	DS	EVDS101096A3	13.2 wt% MgO
HD	EVDIS040297A1	18.4 wt% MgO, r_B=3.44 g/m^2, r_{Na}=3.62 g/m^2	DS	EVDS101096A1	12.8 wt% MgO
HD	EVDIS101896A2	15.9 wt% Al_2O_3, η=35.4 Pa·s	DS	EVDS102396A1	12.7 wt% MgO
OX	12OX13AF1	T_{Cr}=0.997 mg/L	DS	EVDS102396A2	12.1 wt% MgO
OX	12OX17AF1	r_B=5.14 g/m^2, r_{Na}=6.88 g/m^2, T_{Cr}=1.940 mg/L	DS	EVDS102496A1	12.8 wt% MgO
OX	12OX18AF1	19.0 wt% Na_2O, r_B=4.59 g/m^2, r_{Na}=6.80 g/m^2, T_{Cr}=1.057 mg/L	DS	EVDS012297B1	16.1 wt% MgO
OX	4OX6BF1	T_{Cr}=1.155 mg/L	DS	EVDS040297B2	20.7 wt% MgO, r_B=5.16 g/m^2, r_{Na}=5.20 g/m^2
DS	ATLDS11EFB4	12.5 wt% MgO	DS	EVDS040297B1	20.3 wt% MgO, r_B=4.96 g/m^2, r_{Na}=4.90 g/m^2
DS	EVDS021396B2	12.9 wt% MgO, r_B=2.84 g/m^2	DS	EVDS040497B1	23.1 wt% MgO, r_B=8.51 g/m^2, r_{Na}=7.79 g/m^2
DS	EVDS030896A1	11.0 wt% Al_2O_3, η=16.4 Pa·s	DS	EVDS040497B2	21.4 wt% MgO, r_B=6.55 g/m^2, r_{Na}=6.04 g/m^2
DS	EVDS050696B1	13.0 wt% MgO, T_{Cd}=0.021 mg/L			

The calculated TCLP releases are summarized in Table XV for the 163 glasses. The current RCRA and UTS limits for each element are also shown in Table XV for comparison. As can be seen from the summary statistics, the calculated releases of Ag, As, and Ba are an order of magnitude below even the more stringent UTS limits. The conservative order-of-magnitude safety margin for TCLP Cd release, however, has made 2 of the glasses violate the TCLP limit, one of which is also outside of the GCER. The calculated releases of Ni and Pb, are below the UTS limits for all 163 glasses. Four glasses have predicted TCLP Cr releases above the UTS limits. Of these four high-Cr release glasses, two are predicted to have higher than acceptable PCT releases

Table XV. Summary of calculated TCLP releases for the 163 LANL EVB glasses

Element	Current RCRA Limit (mg/L)	UTS Limit (mg/L)	Calculation Limit (mg/L)	Max Calculated Release (mg/L)	Mean Calculated Release (mg/L)	# of Glasses with Calculated Releases > Calculation Limit
Ag	5	0.3	0.03	0.00147	0.00013	0
As	5	5	0.5	0.01660	0.00113	0
Ba	100	7.6	0.76	0.03858	0.00337	0
Cd	1	0.19	0.019	0.03169	0.00098	2
Cr	5	0.86	0.86	1.94042	0.55353	4
Ni	-	5	5	0.90550	0.32795	0
Pb	5	0.37	0.37	0.13196	0.02946	0

Optimized Glass Validation *(Step 9)*

The final step to glass development is the validation/verification of the properties of optimized glasses. This step is outside of the scope of this report. It is recommended that glasses made with the optimized frit covering the expected glass composition region be fabricated using the final glass melter technology. Further, the properties of these glasses should be measured to validate the predictions and assertions of this study.

Discussion and Recommendations

A frit composition was optimized for vitrifying the diverse EVB wastes at LANL, at a waste loading of 25% on an oxide weight basis. Based on model predictions, a majority (roughly 77%) of the glasses formed by combining EVB wastes with 75wt% of the optimized frit will meet the specified set of glass property constraints. The frit composition – 70.26 wt% SiO_2, 8.00 wt% B_2O_3, 5.66 wt% Na_2O, 10.08 wt% Li_2O, and 6.00 wt% Al_2O_3 – was optimized specifically to make good glasses with the maximum amount of variation allowed in the waste composition. We recommend this frit composition for use as a baseline frit in EVB vitrification demonstrations and operations at LANL. Any variation in the restrictions, listed in Table II, may alter the optimum frit composition. If changes arise, it is recommended that calculations and limited testing be performed to re-optimize the frit composition.

Several (23%) of the glasses resulting from mixing (via calculation) the optimized frit with 25 wt% of each of the 163 waste compositions either fall outside the glass composition experimental region and/or the property restrictions set for this study. It is recommended that one of four options be implemented for these compositions: 1) blend wastes to adjust the chemistry, 2) vitrify the waste at a lower WL, 3) test glass compositions before processing, or 4) treat the waste using an alternative system. In particular, it is not clear whether more than 12wt% MgO is compatible with high-durability, low-temperature glasses.

Conservative leaching criteria were used for glass optimization. These include meeting or exceeding Universal Treatment Standard (UTS) limits with the Toxicity Characteristic Leach

Procedure (TCLP), and Environmental Assessment standard in the product consistency test (PCT). These requirements are beyond the regulatory requirements for these wastes; however, they ensure that durable waste glass is produced.

It was difficult to fabricate the two validation glasses at 1050°C from their oxide and carbonate precursors. These glasses took several hours of melting at temperature to form homogeneous glass. It is difficult or impossible to translate this experience to their processability in the melter system. However, testing is recommended to ensure the processability of waste glass compositions, using frit and waste simulants.

Chromate separation was seen in a number of test glasses while melting from oxide and carbonate precursors. It is difficult to assess when a chromate phase may form. An attempt was made in frit design to increase the spinel liquidus temperature in glasses with higher chromium content. This may force the chromium into spinel, rather than having it oxidize and separate into an alkali chromate phase. Both validation glasses, LANL-AL and -AM, formed spinel and not chromate. Large scale prototype testing with waste simulant and pre-fused frit is recommended to determine the propensity of waste streams to chromate separation.

The properties of the optimized glass were not adequately validated (or verified). It is recommended that glasses encompassing the expected processing composition region be fabricated and tested to ensure adequate properties. The fabrication of these glasses should, ideally, be performed using the final melter system before radioactive start-up.

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Appendix: Evaporator Bottoms Waste Compositions

Table AI lists the compositions of evaporator bottoms waste samples measured at LANL, using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) for major components, cold vapor atomic fluorescence for Hg, germanium gamma spectrometry for Am, and alpha proportional counter for Pu. These samples were taken from homogeneous liquid waste streams. Adjustments were made to this composition data to ensure that representative data were used in frit optimization. These adjustments are described in Step 1 of the main report. The resulting compositions in wt% oxides, shown in Table AII, were then used for the glass composition calculations described in this report.

Table AI. Solution concentration of components in EVB waste

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
1	10EVDIST27BF1	< 1	[redacted]	0.0942	< 5	80	19	[redacted]	21	7000	28000	< 5	[redacted]			4600	360	2.42	< 8	NR	0 < 20
~~1~~	~~11EVDIST1BF1~~	~~< 10~~		~~0.0602~~	~~< 50~~	~~70~~	~~15~~		~~< 10~~	~~5700~~	~~23000~~	~~< 50~~				~~4000~~	~~300~~	~~2.52~~	~~< 80~~	~~NR~~	~~0 < 200~~
~~1~~	~~11EVDIST8AF1~~	~~< 1~~		~~0.0251~~	~~< 5~~	~~48~~	~~5.2~~		~~9~~	~~4200~~	~~15000~~	~~< 25~~				~~2300~~	~~110~~	~~1.47~~	~~< 8~~		~~350 < 100~~
~~1~~	~~11EVDIST8BF1~~	~~< 1~~		~~0.0585~~	~~< 5~~	~~79~~	~~16~~		~~20~~	~~6000~~	~~23000~~	~~< 25~~				~~2600~~	~~280~~	~~1.83~~	~~< 8~~		~~730 < 100~~
~~1~~	~~11EVDIST17BF1~~	~~< 1~~		~~0.0364~~	~~< 5~~	~~51~~	~~3~~		~~4.6~~	~~4000~~	~~15000~~	~~< 5~~				~~2300~~	~~140~~	~~1.57~~	~~< 8~~		~~780 < 20~~
1	12EVDIST6AF1	< 1	1700	0.0377	< 5	37	4.7	25000	3.8	5000	20000	< 5	5300	32000	3300	2400	76	1.8	< 8	NR	0 < 20
~~1~~	~~12EVDIST15AF1~~	~~< 1~~		~~0.033~~	~~< 5~~	~~51~~	~~19~~	~~41000~~	~~4.3~~	~~4200~~	~~17000~~	~~< 5~~	~~13000~~	~~64000~~	~~7900~~	~~2100~~	~~120~~	~~1.47~~	~~< 8~~	~~NR~~	~~0 < 20~~
~~1~~	~~12EVDIST15AF1R~~	~~< 1~~		~~0~~	~~< 5~~	~~76~~	~~31~~	~~56000~~	~~6.2~~	~~6600~~	~~26000~~	~~< 5~~	~~17000~~	~~95000~~	~~13000~~	~~3100~~	~~170~~	~~0~~	~~< 8~~	~~NR~~	~~0 < 20~~
1	12EVDIST21AF1	< 1	6500	0.0247	< 5	35	< 1	62000	< 1	3100	15000	< 5	12000	57000	12000	1900	82	1.59	< 8	NR	0 < 20
1	2EVDIST14AF1	< 1	1700	0.0228	15	29	80	11000	3	6200	21000	< 5	7700	14000	3900	2700	150	0.728	< 8	< 20	< 20
1	2EVDIST15BF1	< 1	1400	0.0131	< 5	25	37	64000	< 1	2900	13000	< 5	6800	8400	2500	1900	56	0.29	< 8	< 20	< 20
1	2EVDIST16AF1	< 1	700	0.0062	< 5	11	16	2400	< 1	1100	5100	< 5	2900	2900	1700	670	51	0.159	< 8	< 20	< 20
1	3EVDIST14BF1	< 1	2500	0.0203	< 5	30	37	12000	< 1	3500	14000	< 5	11000	14000	3200	2400	110	0.48	< 8	< 20	< 20
1	3EVDIST20BF1	< 1	430	0.0034	< 5	6.5	7.7	2200	< 1	1600	6300	< 5	470	2600	200	1100	14	0.163	< 8	< 20	< 20
1	3EVDIST24BF1	< 1	1100	0.0138	< 5	7.7	18	2800	< 1	1100	4900	< 5	6100	7600	790	880	18	0.059	< 8	< 20	< 20
1	3EVDIST28BF1	< 1	3800	0.0233	< 5	44	11	31000	< 1	3400	13000	< 5	13000	35000	6400	2800	120	1.54	< 8	< 20	< 20
1	3EVDIST29BF1	< 1	8100	0.0319	< 5	55	14	41000	< 1	5700	25000	< 5	18000	37000	1000	4300	230	1.9	< 8	< 20	< 20
1	3EVDIST31BF1	< 1	3500	0.0242	< 5	30	21	18000	< 1	4400	17000	< 5	9200	25000	6100	3300	120	1.29	< 8	< 20	< 20
1	4EVDIST12BF1A	< 1	2100	0.0084	< 5	22	4.7	30000	< 1	4900	20000	< 5	4400	39000	1500	2600	25	0.504	< 25	< 20	< 20
1	4EVDIST12BF1B	< 1	1700	0.0087	< 5	17	4.7	21000	< 1	3600	15000	< 5	4800	36000	1200	2300	25	0.383	< 25	< 20	< 20
1	4EVDIST21BF1A	< 1	5300	0.113	< 5	19	900	34000	< 1	3000	14000	< 5	43000	56000	1900	1800	190	0.438	< 25	< 20	< 20
1	4EVDIST21BF1B	< 1	8400	0.161	< 5	32	1400	63000	< 1	5000	24000	< 5	62000	69000	3200	2700	280	0.92	< 25	< 20	< 20

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
1	4EVDIST25BF1	< 1	5700	0.122	< 5	24	940	38000	< 1	3600	17000	< 5	45000	57000	2100	2200	180	0.553	< 25	< 20	< 20
1	5EVDIST3BF1	< 1	1100	0.0275	< 5	6	150	7900	< 1	1200	5200	< 5	9900	13000	1000	760	58	0.384	< 25	< 20	< 20
1	5EVDIST8BF1	< 1	1000	0.033	< 5	3	81	7600	< 1	1200	5000	< 5	9800	17000	430	740	75	0.12	< 25	< 20	< 20
1	5EVDIST4BF1	< 1	660	0.0179	< 5	3.3	72	3900	< 1	890	3800	< 5	6100	7000	300	500	33	0.057	< 25	< 20	< 30
1	5EVDIST24BF1	< 1	2700	0.0625	< 5	10	110	32000	< 1	2900	11000	< 5	30000	56000	1000	1700	180	0.742	< 25	< 20	< 20
1	7EVDIST17BF1	< 1	1400	0.0324	< 5	7.5	49	17000	< 1	1900	7100	< 5	16000	25000	420	1000	81	0.258	< 25	< 20	< 20
1	EVDIS090895A2	< 1	1800	0.0439	< 5	16	14	28000	< 1	2400	12000	< 5	19000	41000	990	1300	120	0.389	< 25	< 20	< 20
1	EVDIS090895A1	< 1	1500	0.0336	< 5	11	9	24000	< 1	2300	11000	< 5	16000	34000	840	1300	95	0.177	< 25	< 20	< 20
1	EVDIS091295A1	< 1	770	0.0166	< 5	7	< 5	11000	< 1	2000	8800	< 5	7500	14000	500	1100	48	0.088	< 25	< 20	< 20
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1	EVDIS092595B1	< 1	3800	0.0725	< 5	23	57	47000	< 1	6100	28000	< 5	49000	66000	1700	2800	180	0.562	< 25	< 20	< 20
1	EVDIS092795B1	< 1	2200	0.0441	< 5	14	35	25000	< 1	3700	18000	< 5	28000	52000	1000	1900	120	0.38	< 25	< 20	< 20
1	EVDIS100495A1	< 1	930	0.018	< 5	11	14	9900	< 1	2500	11000	< 5	11000	16000	450	1300	44	0.211	< 25	< 20	< 20
1	EVDIS101095A1	< 1	890	0.013	< 5	9	9	10000	< 1	1800	8100	< 5	6800	17000	470	1100	28	0.188	< 25	< 20	< 20
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1	EVDIS101995A1	1.3	770	0.0178	< 5	9.7	22	8400	< 1	1700	7400	< 5	9800	14000	390	1000	38	0.155	< 25	< 20	< 20
1	EVDIS101995B1	1.5	1500	0.0436	5.4	10	90	21000	< 1	2000	8400	< 5	19000	32000	1100	1200	64	0.301	< 25	< 20	< 20
1	EVDIS102395A1	1.4	400	0.0074	< 5	6.2	8.9	3400	< 1	1000	4200	< 5	3500	5100	350	580	17	0.08	< 25	< 20	< 20
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1	EVDIS122195B1	1.8	5500	0.0657	< 5	17	48	56000	< 1	3800	18000	< 5	41000	110000	5200	2100	180	0.535	< 25	< 20	< 20
1	EVDIS010996A1	< 1	5300	0.0442	6.6	15	85	41000	< 1	3500	15000	< 5	47000	57000	3600	1800	94	0.369	< 25	< 20	< 20

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
1	EVDIS012596B1	< 1	5600	0.0499	< 5	17	89	43000	< 1	4200	18000	< 5	48000	57000	3500	2100	96	0.404	< 25	< 20	< 20
1	EVDIS032296A2	< 1	23000	0.134	13	17	< 1	47000	< 1	3000	11000	< 5	24000	46000	2700	2100	180	0.501	< 25	< 20	< 20
1	EVDIS032296A1	< 1	16000	0.0982	11	16	< 1	45000	< 1	3600	14000	< 5	24000	52000	3400	2400	150	0.452	< 25	< 20	< 20
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†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
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1	EVDIS090696B1	<	1	5800	0.0507	<	5	15	700	42000	<	1	2300	8800	<	5	19000	54000	800	1300	40	0.399	<	25	<	20	< 20
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1	EVDIS100496B1	<	1	2900	0.0426	<	5	20	250	36000		3	3400	15000	<	5	18000	71000	1900	2300	110	0.469	<	25	<	20	< 20
1	EVDIS100896B1	<	1	2900	0.0373	<	5	20	260	39000		20	3900	17000	<	5	19000	53000	1600	2200	90	0.674	<	25	<	20	< 20
1	EVDIS100996B1	<	1	3300	0.0394	<	5	20	160	45000		5	3900	17000	<	5	16000	79000	1200	2300	90	0.471	<	25	<	20	< 20
1	EVDIS101796B2	<	1	3100	0.113	<	5	10	400	29000		250	6100	26000	<	5	41000	54000	1300	3500	200	0.968	<	25	<	20	< 20
1	EVDIS101796B1	<	1	3200	0.0718	<	5	< 1	30	61000		10	5700	35000	<	5	59000	56000	1500	340	20	0.636	<	25	<	20	< 20
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†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
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2	12OX18AF1	NR	0	4500	0.0025	<	5	< 5	1.7	5500	1.4	970	5500	<	5	620	5200	36000	710	26	0.155	<	8	<	20	59
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†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
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3	LRA19F1	NR 0	640	0.005	< 5	< 10	34	1500	< 1	320	1600	< 5	60	1800	3100	200	17	0.129	< 8	< 20	NR 0
3	LRA20F2	NR 0	320	0.0019	< 5	< 10	15	1100	< 1	220	990	< 5	60	1400	1900	150	8.3	0.082	< 8	< 20	NR 0
3	ATLLRA23B	< 1	2200	0.0228	< 5	37	5	11000	< 1	2100	13000	< 5	8100	12000	1700	1300	220	0.905	< 8	< 20	< 20
3	2LR22AF1	< 1	1600	0.0092	< 5	24	6	13000	< 1	2600	11000	< 5	4800	17000	3300	1600	36	0.864	< 8	< 20	< 20
3	2LR22AF2	< 1	1600	0.017	< 5	24	6	13000	< 1	2600	11000	< 5	4800	17000	3300	1600	36	1.25	< 8	< 20	< 20
3	2LR22AF3	< 1	1600	0.0145	< 5	24	6	13000	< 1	2600	11000	< 5	4800	17000	3300	1600	36	1.13	< 8	< 20	< 20
3	ATLLRA23B1	< 1	4000	0.0295	< 5	42	18	14000	< 1	2200	15000	< 5	31000	15000	3400	1800	340	2.11	< 8	< 20	< 20
3	4LR4BF1A	< 1	3000	0.0104	< 5	40	3.9	34000	< 1	7200	26000	< 5	5300	39000	1200	4500	42	0.562	< 8	< 20	< 20
3	4LR4BF1B	< 1	2800	0.0102	< 5	40	3.9	33000	< 1	6600	25000	< 5	5100	36000	1200	4100	42	0.566	< 8	< 20	< 20
3	4LR10BF1C	< 1	2200	0.0092	< 5	37	< 1	33000	< 1	5600	22000	< 5	3800	46000	1000	2300	18	0.387	< 8	< 20	< 20
3	4LR10BF1B	< 1	3200	0.0104	< 5	39	< 1	51000	< 1	9300	34000	< 5	5400	36000	1100	2700	21	0.498	< 8	< 20	< 20
3	4LR10BF1A	< 1	3100	0.0108	< 5	38	< 1	46000	< 1	8700	33000	< 5	5400	33000	2000	2700	21	0.504	< 8	< 20	< 20
3	4LR17BF1	< 1	5000	0.0346	< 5	93	17	81000	< 1	8000	34000	< 5	7800	39000	6600	3800	130	1.16	< 25	< 20	< 20
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4	~~ATL2B1~~	~~< 1~~		~~0.0376~~	~~< 5~~	~~1.8~~	~~< 1~~	~~2200~~	~~< 1~~	~~36~~	~~18000~~	~~< 5~~		~~170~~	~~5600~~	~~5~~	~~< 5~~	~~0.153~~	~~< 8~~	~~< 20~~	~~430~~
4	~~ATL2B2~~	~~< 1~~		~~0.0299~~	~~< 5~~	~~1.8~~	~~< 1~~	~~2100~~	~~< 1~~	~~27~~	~~17000~~	~~< 5~~		~~110~~	~~5400~~	~~5~~	~~< 5~~	~~0.151~~	~~< 8~~	~~< 20~~	~~280~~
4	~~ATL2B3~~	~~< 1~~		~~0.0126~~	~~< 5~~	~~22~~	~~1.6~~	~~14000~~	~~2.2~~	~~2600~~	~~13000~~	~~< 5~~		~~17000~~	~~5700~~	~~1600~~	~~40~~	~~1~~	~~< 8~~	~~NR 0~~	~~< 20~~
4	~~ATL2B4~~	~~< 1~~		~~0.0056~~	~~< 5~~	~~12~~	~~< 1~~	~~6100~~	~~< 1~~	~~1100~~	~~6400~~	~~< 5~~		~~7300~~	~~1800~~	~~740~~	~~17~~	~~0.296~~	~~< 8~~	~~NR 0~~	~~< 20~~

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
4	~~ATL22~~	~~NR~~	~~0~~	~~1000~~	~~0.021~~	~~< 5~~	~~24~~	~~32~~	~~2100~~	~~5.8~~	~~870~~	~~4100~~	~~< 5~~	~~3800~~	~~2300~~	~~10000~~	~~610~~	~~66~~	~~1.99~~	~~< 8~~	~~< 20~~ ~~NR~~ ~~0~~
4	~~ATLT9B~~	~~NR~~	~~0~~	~~1300~~	~~0.108~~	~~< 5~~	~~32~~	~~910~~	~~14000~~	~~16~~	~~6000~~	~~30000~~	~~NR~~	~~0~~	~~17000~~	~~12000~~	~~9500~~	~~3000~~	~~160~~	~~0.383~~	~~< 8~~	~~< 20~~ ~~NR~~ ~~0~~
4	~~ATLT10B~~	~~NR~~	~~0~~	~~3600~~	~~0.13~~	~~< 5~~	~~46~~	~~220~~	~~8100~~	~~18~~	~~6200~~	~~34000~~	~~< 5~~	~~26000~~	~~13000~~	~~11000~~	~~4500~~	~~250~~	~~0.161~~	~~< 8~~	~~< 20~~ ~~380~~ ~~0~~
4	~~ATLT9B2~~	~~< 1~~	~~5~~	~~0.136~~	~~< 5~~	~~< 1~~	~~200~~	~~22000~~	~~< 1~~	~~9000~~	~~54000~~	~~< 5~~	~~1800~~	~~17000~~	~~14000~~	~~4300~~	~~190~~	~~0.224~~	~~< 8~~	~~< 20~~ ~~2.6~~
4	~~ATL14B~~	~~NR~~	~~0~~	~~0.0545~~	~~< 10~~	~~120~~	~~< 2~~	~~9100~~	~~3.2~~	~~1600~~	~~31000~~	~~NR~~	~~0~~	~~3500~~	~~13000~~	~~1600~~	~~< 10~~	~~1.66~~	~~< 20~~	~~< 40~~ ~~310~~ ~~0~~
4	~~ATL12794B~~	~~< 1~~	~~610~~	~~0.0037~~	~~< 5~~	~~19~~	~~8~~	~~1800~~	~~< 1~~	~~700~~	~~3000~~	~~< 5~~	~~7200~~	~~26000~~	~~72000~~	~~460~~	~~36~~	~~0.449~~	~~< 8~~	~~< 20~~ ~~< 20~~
5	ATLDS11EFB1	< 1	2000	0.0091	< 5	27	10	33000	< 1	1300	5800	< 5	17000	44000	3200	1000	89	0.287	< 8	< 20	< 20
5	ATLDS11EFB3	< 1	6700	0.0178	< 5	29	2.1	58000	< 1	2600	11000	< 5	33000	37000	2000	1400	56	0.089	< 8	< 20	< 20
5	ATLDS11EFB2	< 1	8200	0.0094	< 5	11	1.2	39000	< 1	1200	5500	< 5	19000	44000	1200	940	7	0.047	< 8	< 20	< 20
5	ATLDS11EFB4	< 1	6400	0.0078	< 5	7.5	< 1	29000	< 1	1100	4600	< 5	15000	47000	550	920	10	0.039	< 8	< 20	< 20
5	ATLDS11EFB5	< 1	7200	0.0209	< 5	10	< 1	39000	< 1	1500	6300	< 5	21000	38000	390	1100	16	0.104	< 8	< 20	< 20
5	ATLDS11F1B	< 1	4200	0.032	< 5	33	7.4	24000	< 1	1900	7700	< 5	20000	32000	4800	1200	58	0.605	< 8	< 20	< 20
5	ATLDS11EFB6	< 1	5500	0.034	< 5	53	1.2	31000	< 1	1900	6000	< 5	13000	41000	1100	1000	72	0.398	< 8	< 20	< 20
5	ATLDS11F1B2	< 1	8400	0.152	< 5	9.6	12	29000	< 1	3000	12000	< 5	54000	30000	1600	2100	84	0.561	< 8	< 20	< 20
5	ATLDS11F1B1	< 1	6300	0.0907	< 5	12	28	31000	< 1	1900	11000	< 5	38000	31000	2300	1200	61	0.222	< 8	< 20	< 20
5	ATLDS11EF15B	< 1	5800	0.0787	< 5	11	28	38000	< 1	2900	12000	< 5	47000	38000	1200	1700	42	2	< 25	< 20	< 20
5	ATLDS11EF15B1	< 1	7000	0.0598	< 5	11	29	29000	< 1	2800	12000	< 5	40000	40000	1500	1700	54	0.392	< 25	< 20	< 20
5	4DS19BF1A	< 1	6800	0.15	< 5	27	1300	46000	< 1	4200	19000	< 5	50000	58000	3100	2200	200	0.635	< 25	< 20	< 20
5	4DS19BF1B	< 1	6900	0.146	< 5	22	1300	48000	< 1	4000	19000	< 5	51000	58000	2900	2000	230	0.613	< 25	< 20	< 20
5	4DS26BF1A	< 1	5700	0.211	< 5	7.6	490	59000	< 1	4100	17000	< 5	55000	43000	1400	2100	530	0.38	< 25	< 20	< 20
5	4DS26BF1B	< 1	4900	0.19	< 5	7.1	420	49000	< 1	3300	14000	< 5	47000	59000	1100	1900	460	0.298	< 25	< 20	< 20
5	5DS10BF1A	< 1	3700	0.0681	< 5	7.9	81	54000	< 1	2700	12000	< 5	47000	62000	1000	1400	210	0.474	< 25	< 20	< 20

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
5	5DS10BF1B	< 1	4300	0.0696	< 5	7.5	100	43000	< 1	2600	11000	< 5	42000	55000	1000	1400	220	0.387	< 25	< 20	< 20
5	ATLDS11EF15B2	< 1	8900	0.0983	< 5	5.9	140	32000	< 1	3200	16000	< 5	48000	51000	2700	2000	48	0.263	< 25	< 20	< 20
5	ATLDS11EF15B3	< 1	9100	0.0941	< 5	5.1	130	32000	< 1	3200	17000	< 5	52000	52000	2900	2000	52	0.472	< 25	< 20	< 20
5	ATLDS11EF15B4	< 1	5600	0.0662	< 5	14	270	24000	< 1	2800	13000	< 5	36000	43000	7000	1900	60	0.632	< 25	< 20	< 20
5	ATLDS16B	< 1	4800	0.14	< 5	< 1	97	24000	< 1	2900	12000	< 5	48000	43000	3000	1900	280	0.611	< 25	< 20	< 20
5	EVDS090795A1	< 1	3000	0.0678	< 5	15	12	53000	< 1	2800	13000	< 5	30000	79000	1700	1500	180	0.342	< 25	< 20	< 20
5	EVDS092195B1	< 1	3100	0.0565	< 5	16	56	35000	< 1	4900	23000	< 5	36000	64000	1200	2300	160	0.467	< 25	< 20	< 20
5	EVDS100495B1	< 1	3700	0.0606	< 5	18	33	65000	< 1	4100	19000	< 5	31000	75000	1900	2000	99	0.793	< 25	< 20	< 20
5	EVDS100495A1	< 1	1600	0.0471	< 5	8.5	13	26000	< 1	1800	8900	< 5	13000	39000	850	1000	44	0.33	< 25	< 20	< 20
5	EVDS100495A2	< 1	2800	0.0285	< 5	12	17	51000	< 1	2700	13000	< 5	19000	68000	1500	1500	65	0.55	< 25	< 20	< 20
5	EVDS121495A1	< 1	16000	0.152	< 5	40	280	110000	< 1	5700	51000	< 5	51000	72000	51000	3000	600	1.7	< 25	< 20	< 20
5	EVDS121495B1	< 1	7300	0.12	< 5	22	140	93000	< 1	3800	37000	< 5	59000	78000	21000	2500	380	0.912	< 25	< 20	< 20
5	EVDS121595B1	1.3	5200	0.0756	< 5	14	45	49000	< 1	3700	18000	< 5	40000	76000	4900	1800	180	0.637	< 25	< 20	< 20
5	EVDS121495A2	2.3	4400	0.0575	< 5	5.8	6.4	51000	< 1	2800	14000	< 5	41000	80000	2800	910	120	0.416	< 25	< 20	< 20
5	EVDS011896B1	< 1	5600	0.0579	< 5	17	100	42000	< 1	4100	17000	< 5	50000	57000	3400	2000	110	0.486	< 25	< 20	< 20
5	EVDS011896B2	< 1	5900	0.063	< 5	19	79	46000	< 1	4200	17000	< 5	55000	55000	3900	2000	130	0.502	< 25	< 20	< 20
5	EVDS012696B1	< 1	3900	0.0656	< 5	13	113	32000	< 1	2700	11000	< 5	45000	48000	2300	1400	99	0.327	< 25	< 20	< 20
5	EVDS020696B1	< 1	4700	0.0921	< 5	12	150	38000	< 1	3400	14000	< 5	35000	56000	1900	2000	140	0.399	< 25	< 20	< 20
5	EVDS012996B1	< 1	4300	0.0849	< 5	12	140	34000	< 1	2800	13000	< 5	32000	47000	1800	1900	120	0.384	< 25	< 20	< 20
5	EVDS020896B1	< 1	4300	0.0743	< 5	5.7	66	34000	< 1	3200	14000	< 5	35000	52000	1900	1800	130	0.509	< 25	< 20	< 20
5	EVDS020896B2	< 1	3800	0.067	< 5	4.9	59	29000	< 1	2700	13000	< 5	31000	50000	1800	1800	130	0.524	< 25	< 20	< 20
5	EVDS021396B2	< 1	4600	0.0864	< 5	13	115	4100	< 1	2800	14000	< 5	34000	54000	1700	2000	130	1.07	< 25	< 20	< 20
5	EVDS021396B1	< 1	5400	0.0965	13	16	140	46000	< 1	3500	17000	< 5	41000	61000	2200	2500	170	0.558	< 25	< 20	< 20

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
5	EVDS021496B3	< 1	20000	0.107	< 5	8.2	210	53000	< 1	2300	12000	< 5	26000	55000	1900	1400	240	0.68	< 25	< 20	< 20
5	EVDS021496B1	< 1	17000	0.0909	< 5	8.8	260	49000	< 1	2800	11000	< 5	25000	52000	1900	1400	220	0.405	< 25	< 20	< 20
5	EVDS020896B1	< 1	4300	0.0743	< 5	5.7	66	34000	< 1	3200	14000	< 5	35000	52000	1900	1800	130	0.509	< 25	< 20	< 20
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~~5~~	~~EVDS022796B1~~	~~< 1~~	~~18000~~	~~0.0829~~	~~17~~	~~13~~			~~< 1~~	~~2200~~		~~< 5~~	~~25000~~		~~2100~~	~~1400~~	~~230~~	~~0.497~~	~~NR~~ ~~0~~	~~< 20~~	
5	EVDS021496B2	< 1	20000	0.0767	< 5	11	300	62000	< 1	3400	15000	< 5	34000	45000	2300	1500	270	0.486	< 25	< 20	< 20
5	EVDS030896A1	< 1	27000	0.135	12	18	[redacted]		< 1	2200	[redacted]	< 5	26000	[redacted]	3700	1600	150	0.487	NR 0	< 20	
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5	EVDS030896B2	< 1	14000	0.0893	< 5	< 1	< 5	44000	< 1	3700	14000	< 5	24000	52000	3700	2400	150	0.454	< 25	< 20	< 20
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†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
~~5~~	~~EVDS071196A1~~	~~<~~	~~1~~	~~0.0625~~	~~<~~	~~5~~	~~10~~	~~60~~	~~44000~~	~~10~~	~~2700~~	~~8874~~	~~<~~	~~5~~	~~60000~~	~~1300~~	~~1400~~	~~70~~	~~0.256~~	~~<~~ ~~25~~	~~<~~ ~~20~~ ~~<~~ ~~20~~
5	EVDS082196A1	<	1	4500	0.0543	<	5	15	50	29000	<	1	3200	12000	<	5	17000	43000	2900	1700	90	1.1	<	25	<	20	< 20
5	EVDS082196A2	<	1	3200	0.0407	<	5	14	45	20000	<	1	3000	12000	<	5	12000	31000	3900	1900	50	0.745	<	25	<	20	< 20
5	EVDS082196A3	<	1	5400	0.0618	<	5	14	50	33000	<	1	2900	12000	<	5	19000	47000	1700	1500	100	0.124	<	25	<	20	< 20
~~5~~	~~EVDS082396A1~~			~~0.054~~															~~0.156~~							
5	EVDS082196A4	<	1	4800	0.0562	<	5	10	50	30000	<	1	2500	10000	<	5	17000	50000	1400	1400	90	0.109	<	25	<	20	< 20
5	EVDS082696A1	<	1	3300	0.0478	<	5	10	30	28000	<	1	2500	10000	<	5	15000	49000	1000	1600	85	0.178	<	25	<	20	< 20
5	EVDS082796A1	<	1	4200	0.037	<	5	10	50	44000	<	1	2800	11000	<	5	17000	55000	680	1500	50	0.193	<	25	<	20	< 20
5	EVDS082796A2	<	1	4300	0.0372	<	5	10	50	43000	<	1	2900	11000	<	5	20000	54000	780	1700	60	0.168	<	25	<	20	< 20
5	EVDS082696A2	<	1	4000	0.0529	<	5	10	40	34000	<	1	3200	13000	<	5	28000	51000	1300	3100	90	0.176	<	25	<	20	< 20
5	EVDS082996A1	<	1	4400	0.0428	<	5	10	60	41000	<	1	3400	13000	<	5	15000	56000	1100	1600	50	0.179	<	25	<	20	< 20
5	EVDS090596A1	<	1	5100	0.0479	<	5	15	390	41000	<	1	3000	11000	<	5	18000	52000	1100	1400	40	0.299	<	25	<	20	< 20
5	EVDS090696A1	<	1	5300	0.0478	<	5	15	540	40000	<	1	2500	9900	<	5	18000	55000	750	1400	50	0.398	<	25	<	20	< 20
5	EVDS091196A1	<	1	3800	0.0799	<	5	16	1300	48000		30	4000	18000	<	5	33000	64000	2000	2300	90	0.489	<	25	<	20	< 20
5	EVDS091196A2	<	1	3700	0.0459	<	5	16	1400	46000		40	4200	19000	<	5	34000	74000	2000	2300	80	0.487	<	25	<	20	< 20
5	EVDS091396A1	<	1	3400	0.0415		5	10	120	38000	<	1	3300	14000	<	5	20000	79000	2000	1700	90	0.261	<	25	<	20	< 20
5	EVDS091396A2	<	1	3800	0.0465	<	5	10	280	43000		2	3500	16000	<	5	23000	78000	2000	1900	90	0.329	<	25	<	20	< 20
5	EVDS092596A1	<	1	2200	0.0382	<	5	10	170	47000		10	2800	18000	<	5	11000	82000	960	1700	100	0.381	<	25	<	20	< 20
5	EVDS092596A2	<	1	2800	0.0389	<	5	10	240	37000		3	3400	15000	<	5	16000	81000	1400	2000	100	0.35	<	25	<	20	< 20
5	EVDS100496A1	<	1	1700	0.0325	<	5	10	140	35000	<	1	2400	10000	<	5	9400	78000	950	1600	100	0.357	<	25	<	20	< 20
5	EVDS100496A2	<	1	1700	0.034	<	5	10	140	38000	<	1	2700	11000	<	5	10000	71000	1000	1500	90	0.419	<	25	<	20	< 20
5	EVDS101096A2	<	1	1900	0.0396	<	5	10	60	52000	<	1	2500	9900	<	5	13000	84000	500	1500	40	0.392	<	25	<	20	< 20
5	EVDS101096A3	<	1	2100	0.0427	<	5	10	60	57000	<	1	2600	10000	<	5	15000	82000	520	1500	40	0.426	<	25	<	20	< 20

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
5	EVDS101096A1	< 1	2200	0.0455	< 5	10	90	48000	20	3100	14000	< 5	16000	75000	670	2000	50	0.452	< 25	< 20	< 20
5	EVDS102296A1	< 1	2700	0.066	< 5	20	130	41000	70	3500	15000	< 5	20000	63000	890	2000	70	0.53	< 25	< 20	< 20
5	EVDS102396A1	< 1	6100	0.0359	< 5	10	80	45000	30	1900	8500	< 5	13000	66000	1200	1100	50	0.418	< 25	< 20	< 20
5	EVDS102396A2	< 1	4900	0.0503	< 5	10	80	49000	40	2000	8900	< 5	15000	63000	800	1100	30	0.43	< 25	< 20	< 20
5	EVDS102496A1	< 1	6200	0.0333	< 5	10	60	44000	10	1700	7700	< 5	9600	62000	670	1000	30	0.366	< 25	< 20	< 20
~~5~~	~~EVDS112596B1~~	~~< 1~~		~~0.0219~~	~~< 5~~	~~10~~	~~30~~	~~46000~~	~~< 1~~	~~1000~~	~~5100~~	~~< 5~~		~~99000~~	~~130~~	~~580~~	~~25~~	~~0.319~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS112596B2~~	~~< 1~~		~~0.0266~~	~~< 5~~	~~10~~	~~20~~	~~52000~~	~~< 1~~	~~1100~~	~~5400~~	~~< 5~~		~~130000~~	~~140~~	~~730~~	~~10~~	~~0.343~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS112596B3~~	~~< 1~~		~~0.0102~~	~~< 5~~	~~4~~	~~10~~	~~23000~~	~~< 1~~	~~420~~	~~2000~~	~~< 5~~		~~81000~~	~~400~~	~~340~~	~~< 5~~	~~0.147~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS010897A1~~	~~< 1~~		~~0.0173~~	~~< 5~~	~~20~~	~~10~~	~~8100~~	~~2~~	~~1400~~	~~5900~~	~~< 5~~		~~12000~~	~~6400~~	~~990~~	~~30~~	~~2.5~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS010897A2~~	~~< 1~~		~~0.0447~~	~~< 5~~	~~10~~	~~180~~	~~5500~~	~~< 1~~	~~1200~~	~~5600~~	~~< 5~~		~~9400~~	~~820~~	~~720~~	~~20~~	~~0.062~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS010897A3~~	~~< 1~~		~~0.0515~~	~~< 5~~	~~5~~	~~210~~	~~6600~~	~~< 1~~	~~1300~~	~~6200~~	~~< 5~~		~~10000~~	~~1100~~	~~750~~	~~30~~	~~0.115~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS010897A4~~	~~< 1~~		~~0.0471~~	~~< 5~~	~~5~~	~~200~~	~~6100~~	~~< 1~~	~~1200~~	~~5700~~	~~< 5~~		~~9700~~	~~860~~	~~750~~	~~20~~	~~0.068~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS012297B2~~	~~< 1~~		~~0.0453~~	~~< 5~~	~~10~~	~~20~~	~~48000~~	~~< 1~~	~~860~~	~~4200~~	~~< 5~~		~~146000~~	~~170~~	~~500~~	~~190~~	~~0.093~~	~~< 25~~	~~< 20~~	~~< 20~~
5	EVDS012297B1	< 1	[redacted]	0.0484	< 5	10	10	49000	< 1	890	4200	< 5	[redacted]	160000	180	550	200	0.08	< 25	< 20	< 20
~~5~~	~~EVDS012297B4~~	~~< 1~~		~~0.115~~	~~< 5~~	~~3~~	~~40~~	~~8700~~	~~< 1~~	~~1200~~	~~4800~~	~~< 5~~		~~19000~~	~~510~~	~~750~~	~~80~~	~~0.032~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS012297B3~~	~~< 1~~		~~0.113~~	~~< 5~~	~~4~~	~~30~~	~~7400~~	~~< 1~~	~~1300~~	~~5000~~	~~< 5~~		~~16000~~	~~640~~	~~760~~	~~70~~	~~0.059~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS012297B5~~	~~< 1~~		~~0.117~~	~~< 5~~	~~3~~	~~40~~	~~7200~~	~~< 1~~	~~1200~~	~~4700~~	~~< 5~~		~~16000~~	~~530~~	~~750~~	~~70~~	~~0.021~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS012297B6~~	~~< 1~~		~~0.111~~	~~< 5~~	~~3~~	~~40~~	~~8500~~	~~< 1~~	~~1100~~	~~4600~~	~~< 5~~		~~18000~~	~~490~~	~~720~~	~~60~~	~~0.028~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS020397B1~~	~~< 1~~		~~0.0274~~	~~< 5~~	~~3~~	~~20~~	~~8100~~	~~< 1~~	~~780~~	~~3000~~	~~< 5~~		~~23000~~	~~11000~~	~~640~~	~~40~~	~~0.41~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS020697B1~~			~~0.0289~~														~~0.387~~			
~~5~~	~~EVDS020697B2~~	~~< 1~~		~~0.0247~~	~~< 5~~	~~10~~	~~10~~	~~21000~~	~~< 1~~	~~800~~	~~3200~~	~~< 5~~	~~3900~~	~~140000~~	~~160~~	~~480~~	~~30~~	~~0.365~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS022697B1~~	~~< 1~~		~~0.0223~~	~~< 5~~	~~10~~	~~10~~	~~18000~~	~~< 1~~	~~780~~	~~3300~~	~~< 5~~	~~3500~~	~~142000~~	~~70~~	~~530~~	~~30~~	~~0.239~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS022697B2~~	~~< 1~~		~~0.0249~~	~~< 5~~	~~10~~	~~10~~	~~20000~~	~~< 1~~	~~860~~	~~3600~~	~~< 5~~	~~3600~~	~~135000~~	~~250~~	~~560~~	~~20~~	~~0.254~~	~~< 25~~	~~< 20~~	~~< 20~~

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
5	EVDS031197B1	< 1		0.0243	< 5	10	< 1	19000	< 1	840	3400	< 5	3200	152000	100	600	20	0.355	< 25	< 20	< 20
5	EVDS031297A1			0.0415														0.479			
5	EVDS031297B1	< 1		0.0322	< 5	10	< 1	27000	< 1	810	3500	< 5	4300	159000	230	650	50	0.35	< 25	< 20	< 20
5	EVDS031297B2	< 1		0.0354	< 5	10	< 1	31000	< 1	850	3800	< 5	4800	157000	250	640	60	0.376	< 25	< 20	< 20
5	EVDS031897B2	< 1		0.0388	< 5	10	3	32000	< 1	870	3900	< 5	6800	135000	480	530	40	0.349	< 25	< 20	< 20
5	EVDS031897B1	< 1		0.0338	< 5	10	3	27000	< 1	740	3300	< 5	5900	132000	270	480	40	0.304	< 25	< 20	< 20
5	EVDS031997B1	< 1		0.0319	< 5	10	3	24000	< 1	700	3200	< 5	5600	133000	230	470	40	0.304	< 25	< 20	< 20
5	EVDS032497B2	< 1		0.038	< 5	10	4	24000	< 1	1300	5300	< 5	8200	124000	400	1100	70	0.779	< 25	< 20	< 20
5	EVDS032497B1	< 1		0.0453	< 5	10	10	28000	< 1	1700	7100	< 5	12000	122000	590	1300	90	0.959	< 25	< 20	< 20
5	EVDS032597B1	< 1		0.0336	< 5	10	2	23000	< 1	1000	4200	< 5	6000	120000	340	750	50	0.627	< 25	< 20	< 20
5	EVDS031297B3	< 1		0	< 5	10	10	34000	< 1	1200	5300	< 5	7600	133000	440	760	50	0	< 25	< 20	< 20
5	EVDS032697B1	< 1		0.024	< 5	10	3	20000	< 1	1600	6400	< 5	4000	95000	190	1300	40	0.294	< 25	< 20	< 20
5	EVDS032697B2	< 1		0.0332	< 5	10	2	30000	< 1	1000	4500	< 5	4600	143000	290	650	30	0.413	< 25	< 20	< 20
5	EVDS032697B3	< 1		0.0194	< 5	4	2	16000	< 1	630	2700	< 5	2800	109000	110	480	20	0.21	< 25	< 20	< 20
5	EVDS032697A1	< 1		0.0544	< 5	3	2	4300	< 1	1100	3900	< 5	12000	12500	590	790	90	0.092	< 25	< 20	< 20
5	EVDS032797B1	< 1		0.0912	< 5	2	< 1	5900	< 1	1600	6400	< 5	20000	15000	1200	1300	160	0.119	< 25	< 20	< 20
5	EVDS032797B2	< 1	1300	0.0754	< 5	< 1	< 1	4900	< 1	1200	5000	< 5	17000	12000	990	1000	120	0.106	< 25	< 20	< 20
5	EVDS040197B1	< 1	1700	0.0903	< 5	< 1	< 1	6300	< 1	1400	6000	< 5	21000	17000	1200	1200	140	0.155	< 25	< 20	< 20
5	EVDS040197B2	< 1	1600	0.0916	< 5	< 1	< 1	5600	< 1	1400	5800	< 5	20000	15000	1100	1100	130	0.139	< 25	< 20	< 20
5	EVDS040197B3	< 1	1500	0.0844	< 5	< 1	< 1	5100	< 1	1300	5500	< 5	20000	16000	1100	1100	120	0.133	< 25	< 20	< 20
5	EVDS040197B4	< 1	1500	0.0817	< 5	< 1	< 1	5000	< 1	1300	5100	< 5	18000	16000	1000	1000	140	0.136	< 25	< 20	< 20
5	EVDS040297B2	< 1	1900	0.0237	< 5	5	< 1	18000	< 1	700	3000	< 5	3500	111000	100	540	30	0.446	< 25	< 20	< 20
5	EVDS040897A1			0.0182														0.168			

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
~~5~~	~~EVDS040897A2~~			~~0.0131~~														~~0.133~~			
5	EVDS040297B1	< 1	1800	0.0259	< 5	5	< 1	15000	< 1	800	3300	< 5	3800	92000	150	640	40	0.394	< 25	< 20	< 20
~~5~~	~~EVDS040397B1~~	~~< 1~~		~~0.0186~~	~~< 5~~	~~5~~	~~20~~	~~8100~~	~~< 1~~	~~780~~	~~3400~~	~~< 5~~	~~2900~~	~~133000~~	~~230~~	~~590~~	~~20~~	~~0.12~~	~~< 25~~	~~< 20~~	~~< 20~~
~~5~~	~~EVDS040397B2~~	~~< 1~~		~~0.0097~~	~~< 5~~	~~3~~	~~20~~	~~5000~~	~~< 1~~	~~515~~	~~2200~~	~~< 5~~	~~1500~~	~~144000~~	~~80~~	~~470~~	~~< 5~~	~~0.193~~	~~< 25~~	~~< 20~~	~~< 20~~
5	EVDS040497B1	< 1	470	0.0154	< 5	3	20	6700	< 1	650	2500	< 5	2300	141000	400	500	20	0.116	< 25	< 20	< 20
5	EVDS040497B2	< 1	1000	0.0325	< 5	< 5	30	11400	< 1	1100	4500	< 5	5500	122000	780	700	40	0.267	< 25	< 20	< 20
~~5~~	~~EVDS041097B1~~			~~0.0282~~														~~0.33~~			
~~5~~	~~EVDS041097B2~~			~~0.0423~~														~~0.22~~			
~~5~~	~~EVDS041497B1~~			~~0.0297~~														~~0.557~~			
~~5~~	~~EVDS041697B1~~			~~0.0208~~														~~0.256~~			
~~5~~	~~EVDS041697B2~~			~~0.0219~~														~~0.286~~			
~~5~~	~~EVDS041697B3~~			~~0.0271~~														~~0.495~~			
~~5~~	~~EVDS041797B2~~			~~0.0327~~														~~0.393~~			
~~5~~	~~EVDS041797B1~~			~~0.0258~~														~~0.323~~			
~~5~~	~~EVDS041897B1~~			~~0.0216~~														~~0.249~~			
~~5~~	~~EVDS042197B1~~			~~0.0273~~														~~0.302~~			
~~5~~	~~EVDS042197B2~~			~~0.0215~~														~~0.266~~			
~~5~~	~~EVDS042197B3~~			~~0.0301~~														~~0.29~~			
~~5~~	~~EVDS042197B4~~			~~0.0229~~														~~0.245~~			
~~5~~	~~EVDS050597B1~~			~~0.0455~~														~~0.476~~			
~~5~~	~~EVDS050597B2~~			~~0.045~~														~~0.478~~			
~~5~~	~~EVDS050597B3~~			~~0.0416~~														~~0.458~~			
~~5~~	~~EVDS050597B4~~			~~0.0386~~														~~0.5~~			

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
5	EVDS050797B1			0.0063														0.047			
5	EVDS050897B1			0.0206														0.141			
5	EVDS050897B2			0.0174														0.108			
5	EVDS050897B3			0.0184														0.137			
5	EVDS052297B4			0.101														1.44			
5	EVDS052797B1			0.0881														1.22			
5	EVDS060497B1			0.0111														0.8			
6	EVCL042497B1			0.0524														0.19			
6	EVCL042497B2			0.0523														0.179			
6	EVCL042497B3			0.0459														0.169			
6	EVCL040897B1			0.0781														0.172			
6	EVCL040897B2			0.0774														0.137			
6	EVCL040897B3			0.0751														0.144			
6	EVCL040897B4			0.0736														0.137			
6	EVCL040897A1			0.0723														0.141			
6	EVCL040897A2			0.0717														0.137			
6	EVCL040897A3			0.0747														0.142			
6	EVCL040897A4			0.0732														0.149			
6	EVCL040397B1	<	1	0.0801	< 5	2	2	4800	< 1	1200	4600	< 5	16100	17000	980	960	100	0.145	< 25	< 20	< 20
6	EVCL040397B2	<	1	0.0799	< 5	2	< 1	4200	< 1	1150	4400	< 5	14000	14400	880	950	120	0.14	< 25	< 20	< 20
6	EVCL040497B1	<	1	0.102	< 5	3	70	6600	10	1200	5700	< 5	23000	31000	4100	900	70	0.222	< 25	< 20	< 20
6	EVCL040497B2	<	1	0.112	< 5	3	90	6600	10	1300	6200	< 5	26000	12000	4400	970	80	0.198	< 25	< 20	< 20
6	EVCL041497B1			0.0686														0.119			

†	User Sample ID	Ag	Al	Am*	As	Ba	Be	Ca	Cd	Cr	Fe	Hg	K	Mg	Na	Ni	Pb	Pu*	Se	Tl	U
6	~~EVCL041497B2~~			~~0.378~~														~~0.121~~			
6	~~EVCL041497B3~~			~~0.0682~~														~~0.123~~			
6	~~EVCL041497B4~~			~~0.0675~~														~~0.126~~			
6	~~EVCL042897B1~~			~~0.0533~~														~~0.141~~			
6	~~EVCL042897B2~~			~~0.0562~~														~~0.161~~			
6	~~EVCL042897B3~~			~~0.0478~~														~~0.123~~			
6	~~EVCL060497A2~~			~~0.0155~~														~~0.135~~			
6	~~EVCL060497A3~~			~~0.0115~~														~~0.111~~			

*Solution concentrations are in ppm, except for Pu and Am, for which they are g/l.

†Waste types: 1 - hot distillate (HD), 2 - oxalate filtrate (OX), 3 - lean residue (LR), 4 - ATLAS (ATL), 5 - dissolution (DS), and 6 - chloride (CL)

Those wastes crossed out were not considered in calculations; those with grey fields were adjusted and used as described in Step 1.

Table AII. Reduced EVB waste compositions in weight fraction of oxides

†	User Sample ID	Ag_2O	Al_2O_3	Am_2O_3	As_2O_3	BaO	BeO	CaO	CdO	Cr_2O_3	Fe_2O_3	K_2O	MgO	Na_2O	NiO	PbO	PuO_2	TlO_x	U_3O_8
1	10EVDIST27BF1	0.0000	0.0185	0.0009	0.0001	0.0008	0.0005	0.1264	0.0002	0.0943	0.3691	0.0788	0.2153	0.0107	0.0540	0.0051	0.0252	0.0000	0.0002
1	12EVDIST6AF1	0.0000	0.0160	0.0003	0.0000	0.0003	0.0001	0.2457	0.0000	0.0513	0.2008	0.0448	0.3726	0.0312	0.0214	0.0008	0.0143	0.0000	0.0002
1	12EVDIST21AF1	0.0000	0.0347	0.0001	0.0000	0.0002	0.0000	0.3456	0.0000	0.0180	0.0854	0.0576	0.3765	0.0644	0.0096	0.0005	0.0072	0.0000	0.0001
1	2EVDIST14AF1	0.0000	0.0229	0.0002	0.0002	0.0003	0.0022	0.1549	0.0000	0.0912	0.3022	0.0934	0.2337	0.0529	0.0346	0.0023	0.0083	0.0002	0.0002
1	2EVDIST15BF1	0.0000	0.0131	0.0001	0.0000	0.0002	0.0007	0.6272	0.0000	0.0297	0.1302	0.0574	0.0976	0.0236	0.0169	0.0006	0.0023	0.0002	0.0002
1	2EVDIST16AF1	0.0000	0.0375	0.0003	0.0003	0.0005	0.0018	0.1342	0.0000	0.0643	0.2915	0.1396	0.1922	0.0916	0.0341	0.0031	0.0072	0.0009	0.0009
1	3EVDIST14BF1	0.0000	0.0372	0.0002	0.0001	0.0004	0.0011	0.1865	0.0000	0.0568	0.2223	0.1472	0.2579	0.0479	0.0339	0.0019	0.0060	0.0003	0.0003
1	3EVDIST20BF1	0.0000	0.0264	0.0002	0.0003	0.0003	0.0010	0.1410	0.0001	0.1071	0.4124	0.0259	0.1974	0.0123	0.0641	0.0010	0.0084	0.0010	0.0010
1	3EVDIST24BF1	0.0000	0.0405	0.0004	0.0002	0.0002	0.0014	0.1077	0.0000	0.0442	0.1927	0.2021	0.3466	0.0293	0.0308	0.0008	0.0018	0.0006	0.0006
1	3EVDIST28BF1	0.0000	0.0318	0.0001	0.0000	0.0003	0.0002	0.2711	0.0000	0.0311	0.1162	0.0979	0.3627	0.0539	0.0223	0.0012	0.0109	0.0001	0.0001
1	3EVDIST29BF1	0.0000	0.0530	0.0002	0.0000	0.0003	0.0002	0.2801	0.0000	0.0407	0.1745	0.1059	0.2995	0.0066	0.0267	0.0017	0.0105	0.0001	0.0001
1	3EVDIST31BF1	0.0000	0.0368	0.0002	0.0001	0.0003	0.0005	0.1977	0.0000	0.0505	0.1908	0.0870	0.3254	0.0646	0.0330	0.0015	0.0115	0.0002	0.0002
1	4EVDIST12BF1A	0.0000	0.0180	0.0001	0.0000	0.0002	0.0001	0.2681	0.0000	0.0457	0.1827	0.0339	0.4131	0.0129	0.0211	0.0002	0.0036	0.0001	0.0001
1	4EVDIST12BF1B	0.0000	0.0177	0.0001	0.0001	0.0001	0.0001	0.2279	0.0000	0.0408	0.1663	0.0448	0.4629	0.0125	0.0227	0.0003	0.0034	0.0002	0.0002
1	4EVDIST21BF1A	0.0000	0.0306	0.0005	0.0000	0.0001	0.0108	0.2050	0.0000	0.0189	0.0863	0.2232	0.4001	0.0110	0.0099	0.0013	0.0021	0.0001	0.0001
1	4EVDIST21BF1B	0.0000	0.0328	0.0005	0.0000	0.0001	0.0113	0.2566	0.0000	0.0213	0.0999	0.2174	0.3331	0.0126	0.0100	0.0013	0.0030	0.0001	0.0001
1	4EVDIST25BF1	0.0000	0.0307	0.0005	0.0000	0.0001	0.0105	0.2140	0.0000	0.0212	0.0978	0.2182	0.3804	0.0114	0.0113	0.0011	0.0025	0.0001	0.0001
1	5EVDIST3BF1	0.0000	0.0252	0.0005	0.0001	0.0001	0.0071	0.1888	0.0000	0.0300	0.1270	0.2037	0.3682	0.0230	0.0165	0.0015	0.0074	0.0004	0.0004

†	User Sample ID	Ag_2O	Al_2O_3	Am_2O_3	As_2O_3	BaO	BeO	CaO	CdO	Cr_2O_3	Fe_2O_3	K_2O	MgO	Na_2O	NiO	PbO	PuO_2	TlO_x	U_3O_8
1	5EVDIST8BF1	0.0000	0.0213	0.0005	0.0001	0.0001	0.0036	0.1689	0.0000	0.0279	0.1135	0.1875	0.4477	0.0092	0.0150	0.0018	0.0022	0.0004	0.0004
1	5EVDIST4BF1	0.0000	0.0264	0.0005	0.0002	0.0001	0.0060	0.1630	0.0000	0.0389	0.1623	0.2195	0.3468	0.0121	0.0190	0.0015	0.0019	0.0007	0.0010
1	5EVDIST24BF1	0.0000	0.0179	0.0003	0.0000	0.0001	0.0015	0.2212	0.0000	0.0209	0.0777	0.1785	0.4587	0.0067	0.0107	0.0014	0.0041	0.0001	0.0001
1	7EVDIST17BF1	0.0000	0.0184	0.0003	0.0001	0.0001	0.0013	0.2337	0.0000	0.0273	0.0997	0.1893	0.4072	0.0056	0.0125	0.0012	0.0029	0.0002	0.0002
1	EVDIS090895A2	0.0000	0.0154	0.0003	0.0000	0.0001	0.0002	0.2497	0.0000	0.0224	0.1094	0.1459	0.4333	0.0085	0.0105	0.0012	0.0028	0.0001	0.0001
1	EVDIS090895A1	0.0000	0.0150	0.0003	0.0000	0.0001	0.0002	0.2514	0.0000	0.0252	0.1177	0.1443	0.4220	0.0085	0.0124	0.0011	0.0015	0.0002	0.0002
1	EVDIS091295A1	0.0000	0.0155	0.0003	0.0001	0.0001	0.0002	0.2314	0.0000	0.0439	0.1892	0.1358	0.3490	0.0101	0.0210	0.0011	0.0015	0.0003	0.0003
1	EVDIS091395A1	0.0000	0.0157	0.0003	0.0000	0.0001	0.0016	0.2619	0.0000	0.0194	0.0781	0.1456	0.4462	0.0189	0.0089	0.0009	0.0022	0.0001	0.0001
1	EVDIS092595B1	0.0000	0.0172	0.0003	0.0000	0.0001	0.0005	0.2227	0.0000	0.0302	0.1355	0.1999	0.3705	0.0078	0.0121	0.0009	0.0022	0.0001	0.0001
1	EVDIS092795B1	0.0000	0.0152	0.0002	0.0000	0.0001	0.0005	0.1807	0.0000	0.0279	0.1329	0.1742	0.4453	0.0070	0.0125	0.0010	0.0022	0.0001	0.0001
1	EVDIS100495A1	0.0000	0.0162	0.0002	0.0001	0.0002	0.0005	0.1800	0.0000	0.0475	0.2044	0.1722	0.3448	0.0079	0.0215	0.0009	0.0031	0.0003	0.0003
1	EVDIS101095A1	0.0000	0.0175	0.0002	0.0001	0.0001	0.0004	0.2053	0.0000	0.0386	0.1699	0.1202	0.4135	0.0093	0.0205	0.0006	0.0031	0.0003	0.0003
1	EVDIS100695B1	0.0000	0.0146	0.0002	0.0000	0.0001	0.0032	0.2285	0.0000	0.0247	0.1038	0.2113	0.3911	0.0073	0.0115	0.0009	0.0025	0.0001	0.0001
1	EVDIS101995A1	0.0000	0.0164	0.0003	0.0001	0.0002	0.0010	0.1864	0.0000	0.0394	0.1678	0.1872	0.3682	0.0083	0.0202	0.0009	0.0028	0.0004	0.0004
1	EVDIS101995B1	0.0000	0.0159	0.0004	0.0001	0.0001	0.0020	0.2330	0.0000	0.0232	0.0953	0.1815	0.4208	0.0118	0.0121	0.0008	0.0027	0.0002	0.0002
1	EVDIS102395A1	0.0001	0.0200	0.0003	0.0002	0.0003	0.0009	0.1772	0.0000	0.0544	0.2236	0.1570	0.3149	0.0176	0.0275	0.0010	0.0034	0.0008	0.0008
1	EVDIS102495B1	0.0000	0.0543	0.0005	0.0000	0.0002	0.0032	0.2105	0.0000	0.0326	0.1369	0.1483	0.2721	0.1168	0.0151	0.0025	0.0069	0.0001	0.0001
1	EVDIS121895A1	0.0000	0.0200	0.0002	0.0000	0.0001	0.0002	0.2379	0.0000	0.0167	0.0744	0.1630	0.4660	0.0122	0.0071	0.0006	0.0015	0.0001	0.0001
1	EVDIS122195B1	0.0000	0.0205	0.0002	0.0000	0.0001	0.0004	0.2179	0.0000	0.0154	0.0716	0.1373	0.5072	0.0195	0.0074	0.0008	0.0017	0.0001	0.0001
1	EVDIS010996A1	0.0000	0.0284	0.0002	0.0000	0.0001	0.0009	0.2293	0.0000	0.0204	0.0857	0.2263	0.3777	0.0194	0.0092	0.0006	0.0017	0.0001	0.0001
1	EVDIS012596B1	0.0000	0.0288	0.0002	0.0000	0.0001	0.0009	0.2312	0.0000	0.0236	0.0989	0.2222	0.3632	0.0181	0.0103	0.0006	0.0018	0.0001	0.0001
1	EVDIS032296A2	0.0000	0.1344	0.0006	0.0001	0.0001	0.0000	0.2869	0.0000	0.0191	0.0686	0.1261	0.3327	0.0159	0.0117	0.0012	0.0025	0.0001	0.0001
1	EVDIS032296A1	0.0000	0.0918	0.0004	0.0001	0.0001	0.0000	0.2698	0.0000	0.0225	0.0858	0.1239	0.3695	0.0196	0.0131	0.0010	0.0022	0.0001	0.0001
1	EVDIS 062596B2	0.0000	0.0000	0.0005	0.0000	0.0001	0.0008	0.4142	0.0000	0.0234	0.0827	0.1252	0.3273	0.0147	0.0087	0.0005	0.0018	0.0001	0.0001
1	EVDIS082296B1	0.0000	0.0255	0.0003	0.0000	0.0001	0.0009	0.2143	0.0000	0.0455	0.1725	0.1062	0.3771	0.0313	0.0219	0.0007	0.0035	0.0001	0.0001
1	EVDIS082796B1	0.0000	0.0278	0.0002	0.0000	0.0001	0.0007	0.2624	0.0000	0.0231	0.0847	0.1308	0.4500	0.0073	0.0113	0.0006	0.0008	0.0001	0.0001
1	EVDIS082396B1	0.0000	0.0269	0.0003	0.0000	0.0001	0.0006	0.2390	0.0000	0.0235	0.0862	0.1755	0.4248	0.0081	0.0134	0.0007	0.0008	0.0001	0.0001
1	EVDIS090696B1	0.0000	0.0388	0.0003	0.0000	0.0001	0.0097	0.2935	0.0000	0.0168	0.0628	0.1143	0.4472	0.0054	0.0083	0.0003	0.0023	0.0001	0.0001
1	EVDIS091096B1	0.0000	0.0228	0.0003	0.0000	0.0000	0.0058	0.2551	0.0000	0.0172	0.0695	0.0927	0.5173	0.0047	0.0093	0.0003	0.0046	0.0001	0.0001
1	EVDIS091196B1	0.0000	0.0216	0.0002	0.0000	0.0001	0.0085	0.2647	0.0000	0.0213	0.0902	0.1140	0.4575	0.0069	0.0105	0.0004	0.0038	0.0001	0.0001
1	EVDIS091796B2	0.0000	0.0215	0.0002	0.0000	0.0001	0.0048	0.2498	0.0000	0.0277	0.1123	0.1032	0.4559	0.0111	0.0109	0.0004	0.0019	0.0001	0.0001
1	EVDIS091796B1	0.0000	0.0211	0.0002	0.0000	0.0001	0.0034	0.2396	0.0000	0.0255	0.1049	0.0926	0.4867	0.0108	0.0125	0.0008	0.0016	0.0001	0.0001
1	EVDIS100496B1	0.0000	0.0171	0.0002	0.0000	0.0001	0.0031	0.2218	0.0000	0.0219	0.0944	0.0955	0.5184	0.0113	0.0129	0.0007	0.0023	0.0001	0.0001
1	EVDIS100896B1	0.0000	0.0189	0.0002	0.0000	0.0001	0.0035	0.2650	0.0001	0.0277	0.1180	0.1111	0.4267	0.0105	0.0136	0.0007	0.0037	0.0001	0.0001
1	EVDIS100996B1	0.0000	0.0174	0.0002	0.0000	0.0001	0.0018	0.2484	0.0000	0.0225	0.0959	0.0760	0.5169	0.0064	0.0115	0.0005	0.0021	0.0001	0.0001
1	EVDIS101796B2	0.0000	0.0174	0.0005	0.0000	0.0000	0.0046	0.1698	0.0012	0.0373	0.1556	0.2067	0.3747	0.0073	0.0186	0.0013	0.0046	0.0001	0.0001
1	EVDIS101796B1	0.0000	0.0136	0.0002	0.0000	0.0000	0.0003	0.2706	0.0000	0.0264	0.1587	0.2254	0.2944	0.0064	0.0014	0.0001	0.0023	0.0001	0.0001
1	EVDIS102296B1	0.0000	0.0161	0.0003	0.0000	0.0001	0.0026	0.2294	0.0005	0.0351	0.1487	0.1445	0.3912	0.0092	0.0178	0.0005	0.0038	0.0001	0.0001
1	EVDIS102996B1	0.0000	0.0361	0.0006	0.0000	0.0001	0.0054	0.2418	0.0001	0.0085	0.0395	0.1166	0.5387	0.0028	0.0059	0.0007	0.0029	0.0002	0.0002
1	EVDIS031197B1	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.1155	0.0000	0.0095	0.0359	0.0244	0.8038	0.0017	0.0061	0.0004	0.0022	0.0001	0.0001
1	EVDIS040297A1	0.0000	0.0194	0.0002	0.0000	0.0001	0.0000	0.1631	0.0000	0.0089	0.0347	0.0286	0.7343	0.0015	0.0058	0.0004	0.0030	0.0001	0.0001

†	User Sample ID	Ag_2O	Al_2O_3	Am_2O_3	As_2O_3	BaO	BeO	CaO	CdO	Cr_2O_3	Fe_2O_3	K_2O	MgO	Na_2O	NiO	PbO	PuO_2	TlO_x	U_3O_8
1	EVDIS101896A2	0.0000	0.4560	0.0000	0.0002	0.0004	0.0000	0.0000	0.0000	0.0456	0.0000	0.4442	0.0000	0.0497	0.0003	0.0033	0.0000	0.0003	0.0000
2	12OX13AF1	0.0000	0.0190	0.0001	0.0000	0.0002	0.0002	0.2158	0.0000	0.0252	0.0970	0.0587	0.3273	0.2328	0.0110	0.0007	0.0117	0.0000	0.0001
2	12OX17AF1	0.0000	0.0144	0.0001	0.0001	0.0004	0.0001	0.1269	0.0000	0.0299	0.1116	0.0235	0.2103	0.4603	0.0122	0.0009	0.0091	0.0000	0.0002
2	12OX18AF1	0.0000	0.0734	0.0000	0.0001	0.0001	0.0001	0.0937	0.0000	0.0173	0.0957	0.0091	0.1050	0.5909	0.0110	0.0005	0.0021	0.0003	0.0008
2	4OX6BF1	0.0000	0.0182	0.0001	0.0001	0.0002	0.0009	0.2009	0.0000	0.0396	0.1483	0.0452	0.2777	0.2365	0.0244	0.0004	0.0072	0.0002	0.0002
2	5OX9BF1	0.0000	0.0243	0.0004	0.0001	0.0001	0.0034	0.1691	0.0000	0.0212	0.0950	0.2329	0.4208	0.0101	0.0135	0.0008	0.0079	0.0003	0.0003
2	9OX22AF1	0.0000	0.0163	0.0002	0.0000	0.0001	0.0004	0.2194	0.0000	0.0245	0.1046	0.1889	0.4219	0.0085	0.0106	0.0009	0.0035	0.0001	0.0001
2	EVOX041096B1	0.0000	0.0246	0.0003	0.0000	0.0002	0.0000	0.4128	0.0000	0.0409	0.3893	0.0830	0.0000	0.0275	0.0090	0.0007	0.0110	0.0002	0.0002
3	12LR21AF1	0.0000	0.0326	0.0001	0.0000	0.0002	0.0001	0.3029	0.0000	0.0164	0.0829	0.1025	0.3654	0.0782	0.0093	0.0008	0.0084	0.0000	0.0001
3	LRA19F1	0.0000	0.0634	0.0004	0.0005	0.0008	0.0070	0.1553	0.0001	0.0346	0.1693	0.0053	0.2208	0.3092	0.0188	0.0019	0.0108	0.0017	0.0000
3	LRA20F2	0.0000	0.0474	0.0002	0.0007	0.0012	0.0046	0.1702	0.0001	0.0356	0.1566	0.0080	0.2568	0.2833	0.0211	0.0014	0.0102	0.0025	0.0000
3	ATLLRA23B	0.0000	0.0392	0.0003	0.0001	0.0006	0.0002	0.2050	0.0000	0.0409	0.2475	0.1299	0.2650	0.0305	0.0220	0.0045	0.0136	0.0003	0.0003
3	2LR22AF1	0.0000	0.0263	0.0001	0.0001	0.0003	0.0002	0.2233	0.0000	0.0467	0.1931	0.0710	0.3461	0.0546	0.0250	0.0007	0.0120	0.0003	0.0003
3	2LR22AF2	0.0000	0.0262	0.0002	0.0001	0.0003	0.0002	0.2221	0.0000	0.0464	0.1920	0.0706	0.3442	0.0543	0.0249	0.0007	0.0173	0.0003	0.0003
3	2LR22AF3	0.0000	0.0262	0.0002	0.0001	0.0003	0.0002	0.2225	0.0000	0.0465	0.1924	0.0707	0.3448	0.0544	0.0249	0.0007	0.0156	0.0003	0.0003
3	ATLLRA23B1	0.0000	0.0440	0.0002	0.0001	0.0004	0.0004	0.1608	0.0000	0.0264	0.1761	0.3066	0.2042	0.0376	0.0188	0.0043	0.0196	0.0002	0.0002
3	4LR4BF1A	0.0000	0.0225	0.0001	0.0000	0.0003	0.0001	0.2665	0.0000	0.0590	0.2082	0.0358	0.3623	0.0091	0.0321	0.0004	0.0036	0.0001	0.0001
3	4LR4BF1B	0.0000	0.0222	0.0001	0.0000	0.0003	0.0001	0.2735	0.0000	0.0571	0.2117	0.0364	0.3536	0.0096	0.0309	0.0004	0.0038	0.0001	0.0001
3	4LR10BF1C	0.0000	0.0169	0.0001	0.0000	0.0002	0.0000	0.2647	0.0000	0.0469	0.1803	0.0262	0.4372	0.0077	0.0168	0.0002	0.0025	0.0001	0.0001
3	4LR10BF1B	0.0000	0.0204	0.0001	0.0000	0.0002	0.0000	0.3403	0.0000	0.0648	0.2318	0.0310	0.2847	0.0071	0.0164	0.0002	0.0027	0.0001	0.0001
3	4LR10BF1A	0.0000	0.0211	0.0001	0.0000	0.0002	0.0000	0.3276	0.0000	0.0647	0.2401	0.0331	0.2785	0.0137	0.0175	0.0002	0.0029	0.0001	0.0001
3	4LR17BF1	0.0000	0.0248	0.0001	0.0000	0.0004	0.0002	0.4199	0.0000	0.0433	0.1801	0.0348	0.2396	0.0330	0.0179	0.0007	0.0049	0.0001	0.0001
5	ATLDS11EFB1	0.0000	0.0169	0.0001	0.0000	0.0002	0.0002	0.2910	0.0000	0.0120	0.0523	0.1291	0.4599	0.0272	0.0080	0.0009	0.0020	0.0001	0.0001
5	ATLDS11EFB3	0.0000	0.0416	0.0001	0.0000	0.0002	0.0000	0.3765	0.0000	0.0176	0.0730	0.1844	0.2846	0.0125	0.0083	0.0004	0.0005	0.0001	0.0001
5	ATLDS11EFB2	0.0000	0.0631	0.0001	0.0000	0.0001	0.0000	0.3137	0.0000	0.0101	0.0452	0.1316	0.4194	0.0093	0.0069	0.0001	0.0003	0.0001	0.0001
5	ATLDS11EFB4	0.0000	0.0552	0.0001	0.0000	0.0001	0.0000	0.2611	0.0000	0.0103	0.0423	0.1163	0.5016	0.0048	0.0075	0.0001	0.0003	0.0001	0.0001
5	ATLDS11EFB5	0.0000	0.0581	0.0001	0.0000	0.0001	0.0000	0.3290	0.0000	0.0132	0.0543	0.1525	0.3799	0.0032	0.0084	0.0001	0.0007	0.0001	0.0001
5	ATLDS11F1B	0.0000	0.0405	0.0002	0.0000	0.0003	0.0001	0.2415	0.0000	0.0200	0.0792	0.1732	0.3816	0.0465	0.0110	0.0006	0.0049	0.0002	0.0002
5	ATLDS11EFB6	0.0000	0.0494	0.0002	0.0000	0.0004	0.0000	0.2907	0.0000	0.0186	0.0575	0.1050	0.4556	0.0099	0.0085	0.0007	0.0030	0.0002	0.0002
5	ATLDS11F1B2	0.0000	0.0580	0.0008	0.0000	0.0001	0.0002	0.2092	0.0000	0.0226	0.0884	0.3353	0.2564	0.0111	0.0138	0.0007	0.0033	0.0001	0.0001
5	ATLDS11F1B1	0.0000	0.0489	0.0005	0.0000	0.0001	0.0004	0.2512	0.0000	0.0161	0.0911	0.2650	0.2976	0.0180	0.0088	0.0005	0.0015	0.0001	0.0001
5	ATLDS11EF15B	0.0000	0.0373	0.0004	0.0000	0.0001	0.0004	0.2553	0.0000	0.0203	0.0824	0.2718	0.3025	0.0078	0.0104	0.0003	0.0109	0.0001	0.0001
5	ATLDS11EF15B1	0.0000	0.0492	0.0003	0.0000	0.0001	0.0004	0.2129	0.0000	0.0215	0.0900	0.2528	0.3479	0.0106	0.0113	0.0004	0.0023	0.0001	0.0001
5	4DS19BF1A	0.0000	0.0331	0.0006	0.0000	0.0001	0.0131	0.2340	0.0000	0.0223	0.0988	0.2190	0.3497	0.0152	0.0102	0.0011	0.0026	0.0001	0.0001
5	4DS19BF1B	0.0000	0.0332	0.0005	0.0000	0.0001	0.0130	0.2413	0.0000	0.0210	0.0976	0.2207	0.3455	0.0140	0.0091	0.0013	0.0025	0.0001	0.0001
5	4DS26BF1A	0.0000	0.0288	0.0008	0.0000	0.0000	0.0051	0.3110	0.0000	0.0226	0.0916	0.2496	0.2686	0.0071	0.0101	0.0031	0.0016	0.0001	0.0001
5	4DS26BF1B	0.0000	0.0252	0.0007	0.0000	0.0000	0.0045	0.2629	0.0000	0.0185	0.0768	0.2171	0.3751	0.0057	0.0093	0.0027	0.0013	0.0001	0.0001
5	5DS10BF1A	0.0000	0.0187	0.0003	0.0000	0.0000	0.0008	0.2847	0.0000	0.0149	0.0646	0.2133	0.3874	0.0051	0.0067	0.0012	0.0020	0.0001	0.0001
5	5DS10BF1B	0.0000	0.0249	0.0003	0.0000	0.0000	0.0012	0.2598	0.0000	0.0164	0.0679	0.2185	0.3938	0.0058	0.0077	0.0015	0.0019	0.0001	0.0001
5	ATLDS11EF15B2	0.0000	0.0510	0.0004	0.0000	0.0000	0.0017	0.1916	0.0000	0.0200	0.0979	0.2474	0.3618	0.0156	0.0109	0.0003	0.0013	0.0001	0.0001
5	ATLDS11EF15B3	0.0000	0.0503	0.0004	0.0000	0.0000	0.0015	0.1847	0.0000	0.0193	0.1003	0.2584	0.3557	0.0161	0.0105	0.0003	0.0022	0.0001	0.0001

†	User Sample ID	Ag_2O	Al_2O_3	Am_2O_3	As_2O_3	BaO	BeO	CaO	CdO	Cr_2O_3	Fe_2O_3	K_2O	MgO	Na_2O	NiO	PbO	PuO_2	TlO_x	U_3O_8
5	ATLDS11EF15B4	0.0000	0.0391	0.0004	0.0000	0.0001	0.0039	0.1749	0.0000	0.0213	0.0968	0.2259	0.3714	0.0492	0.0126	0.0005	0.0037	0.0001	0.0001
5	ATLDS16B	0.0000	0.0324	0.0007	0.0000	0.0000	0.0014	0.1691	0.0000	0.0213	0.0864	0.2912	0.3590	0.0204	0.0122	0.0022	0.0035	0.0001	0.0001
5	EVDS090795A1	0.0000	0.0147	0.0003	0.0000	0.0001	0.0001	0.2716	0.0000	0.0150	0.0681	0.1324	0.4798	0.0084	0.0070	0.0010	0.0014	0.0001	0.0001
5	EVDS092195B1	0.0000	0.0167	0.0002	0.0000	0.0001	0.0006	0.1973	0.0000	0.0288	0.1325	0.1747	0.4275	0.0065	0.0118	0.0010	0.0021	0.0001	0.0001
5	EVDS100495B1	0.0000	0.0167	0.0002	0.0000	0.0001	0.0003	0.3061	0.0000	0.0202	0.0914	0.1257	0.4185	0.0086	0.0086	0.0005	0.0030	0.0001	0.0001
5	EVDS100495A1	0.0000	0.0156	0.0003	0.0000	0.0001	0.0003	0.2651	0.0000	0.0192	0.0927	0.1141	0.4713	0.0084	0.0093	0.0005	0.0027	0.0002	0.0002
5	EVDS100495A2	0.0000	0.0158	0.0001	0.0000	0.0001	0.0002	0.2997	0.0000	0.0166	0.0781	0.0961	0.4736	0.0085	0.0080	0.0004	0.0026	0.0001	0.0001
5	EVDS121495A1	0.0000	0.0417	0.0003	0.0000	0.0001	0.0015	0.2995	0.0000	0.0162	0.1419	0.1196	0.2323	0.1338	0.0074	0.0018	0.0037	0.0000	0.0000
5	EVDS121495B1	0.0000	0.0226	0.0003	0.0000	0.0001	0.0009	0.3009	0.0000	0.0128	0.1223	0.1643	0.2991	0.0655	0.0074	0.0014	0.0024	0.0001	0.0001
5	EVDS121595B1	0.0000	0.0239	0.0003	0.0000	0.0001	0.0004	0.2356	0.0000	0.0186	0.0884	0.1656	0.4330	0.0227	0.0079	0.0010	0.0025	0.0001	0.0001
5	EVDS121495A2	0.0000	0.0204	0.0002	0.0000	0.0000	0.0001	0.2468	0.0000	0.0142	0.0692	0.1708	0.4588	0.0131	0.0040	0.0006	0.0016	0.0001	0.0001
5	EVDS011896B1	0.0000	0.0289	0.0002	0.0000	0.0001	0.0011	0.2264	0.0000	0.0231	0.0936	0.2320	0.3641	0.0177	0.0098	0.0007	0.0021	0.0001	0.0001
5	EVDS011896B2	0.0000	0.0294	0.0002	0.0000	0.0001	0.0008	0.2392	0.0000	0.0228	0.0903	0.2462	0.3389	0.0195	0.0095	0.0007	0.0021	0.0001	0.0001
5	EVDS012696B1	0.0000	0.0250	0.0003	0.0000	0.0001	0.0015	0.2139	0.0000	0.0189	0.0751	0.2590	0.3802	0.0148	0.0085	0.0007	0.0018	0.0001	0.0001
5	EVDS020696B1	0.0000	0.0279	0.0004	0.0000	0.0001	0.0018	0.2355	0.0000	0.0220	0.0886	0.1867	0.4112	0.0113	0.0113	0.0010	0.0020	0.0001	0.0001
5	EVDS012996B1	0.0000	0.0290	0.0004	0.0000	0.0001	0.0020	0.2397	0.0000	0.0206	0.0936	0.1942	0.3926	0.0122	0.0122	0.0009	0.0022	0.0001	0.0001
5	EVDS020896B1	0.0000	0.0271	0.0004	0.0000	0.0000	0.0009	0.2240	0.0000	0.0220	0.0943	0.1985	0.4060	0.0121	0.0108	0.0009	0.0027	0.0001	0.0001
5	EVDS020896B2	0.0000	0.0262	0.0004	0.0000	0.0000	0.0008	0.2089	0.0000	0.0203	0.0957	0.1922	0.4268	0.0125	0.0118	0.0010	0.0031	0.0001	0.0001
5	EVDS021396B2	0.0000	0.0356	0.0005	0.0000	0.0001	0.0018	0.0331	0.0000	0.0236	0.1156	0.2364	0.5169	0.0132	0.0147	0.0012	0.0070	0.0001	0.0001
5	EVDS021396B1	0.0000	0.0279	0.0004	0.0001	0.0001	0.0015	0.2484	0.0000	0.0197	0.0938	0.1906	0.3903	0.0114	0.0123	0.0010	0.0024	0.0001	0.0001
5	EVDS021496B3	0.0000	0.1071	0.0004	0.0000	0.0000	0.0023	0.2964	0.0000	0.0134	0.0686	0.1252	0.3645	0.0102	0.0071	0.0015	0.0031	0.0001	0.0001
5	EVDS021496B1	0.0000	0.0975	0.0004	0.0000	0.0000	0.0031	0.2936	0.0000	0.0175	0.0674	0.1290	0.3692	0.0110	0.0076	0.0015	0.0020	0.0001	0.0001
5	EVDS020896B1	0.0000	0.0271	0.0004	0.0000	0.0000	0.0009	0.2240	0.0000	0.0220	0.0943	0.1985	0.4060	0.0121	0.0108	0.0009	0.0027	0.0001	0.0001
5	EVDS021496B2	0.0000	0.1021	0.0003	0.0000	0.0000	0.0032	0.3305	0.0000	0.0189	0.0817	0.1560	0.2843	0.0118	0.0073	0.0016	0.0021	0.0001	0.0001
5	EVDS030896A1	0.0000	0.2603	0.0010	0.0001	0.0001	0.0010	0.1346	0.0000	0.0231	0.0468	0.2255	0.2510	0.0359	0.0147	0.0017	0.0040	0.0002	0.0001
5	EVDS030896B2	0.0000	0.0816	0.0004	0.0000	0.0000	0.0001	0.2679	0.0000	0.0235	0.0871	0.1258	0.3752	0.0217	0.0133	0.0010	0.0022	0.0001	0.0001
5	EVDS050696B1	0.0000	0.0000	0.0004	0.0000	0.0001	0.0005	0.2852	0.0008	0.0324	0.1295	0.0000	0.5183	0.0092	0.0179	0.0003	0.0051	0.0001	0.0001
5	EVDS082196A1	0.0000	0.0359	0.0003	0.0000	0.0001	0.0008	0.2416	0.0000	0.0279	0.1022	0.1219	0.4246	0.0233	0.0129	0.0008	0.0074	0.0001	0.0001
5	EVDS082196A2	0.0000	0.0334	0.0003	0.0001	0.0001	0.0010	0.2178	0.0000	0.0341	0.1335	0.1125	0.4000	0.0409	0.0188	0.0006	0.0066	0.0002	0.0002
5	EVDS082196A3	0.0000	0.0401	0.0003	0.0000	0.0001	0.0008	0.2560	0.0000	0.0235	0.0951	0.1269	0.4320	0.0127	0.0106	0.0009	0.0008	0.0001	0.0001
5	EVDS082196A4	0.0000	0.0370	0.0003	0.0000	0.0001	0.0008	0.2413	0.0000	0.0210	0.0822	0.1177	0.4767	0.0109	0.0102	0.0008	0.0007	0.0001	0.0001
5	EVDS082696A1	0.0000	0.0268	0.0003	0.0000	0.0001	0.0005	0.2378	0.0000	0.0222	0.0868	0.1097	0.4931	0.0082	0.0124	0.0008	0.0012	0.0001	0.0001
5	EVDS082796A1	0.0000	0.0278	0.0002	0.0000	0.0001	0.0007	0.3047	0.0000	0.0203	0.0778	0.1014	0.4514	0.0045	0.0094	0.0004	0.0011	0.0001	0.0001
5	EVDS082796A2	0.0000	0.0283	0.0002	0.0000	0.0001	0.0007	0.2960	0.0000	0.0209	0.0774	0.1185	0.4405	0.0052	0.0106	0.0005	0.0009	0.0001	0.0001
5	EVDS082696A2	0.0000	0.0267	0.0003	0.0000	0.0001	0.0006	0.2370	0.0000	0.0233	0.0926	0.1680	0.4212	0.0087	0.0197	0.0007	0.0010	0.0001	0.0001
5	EVDS082996A1	0.0000	0.0292	0.0002	0.0000	0.0001	0.0008	0.2843	0.0000	0.0246	0.0921	0.0895	0.4601	0.0073	0.0101	0.0004	0.0010	0.0001	0.0001
5	EVDS090596A1	0.0000	0.0347	0.0002	0.0000	0.0001	0.0055	0.2911	0.0000	0.0222	0.0798	0.1100	0.4375	0.0075	0.0090	0.0003	0.0017	0.0001	0.0001
5	EVDS090696A1	0.0000	0.0357	0.0002	0.0000	0.0001	0.0075	0.2817	0.0000	0.0184	0.0712	0.1091	0.4590	0.0051	0.0090	0.0004	0.0023	0.0001	0.0001
5	EVDS091196A1	0.0000	0.0196	0.0003	0.0000	0.0001	0.0139	0.2585	0.0001	0.0225	0.0991	0.1530	0.4084	0.0104	0.0113	0.0005	0.0021	0.0001	0.0001
5	EVDS091196A2	0.0000	0.0179	0.0002	0.0000	0.0001	0.0140	0.2327	0.0002	0.0222	0.0982	0.1481	0.4436	0.0097	0.0106	0.0004	0.0020	0.0001	0.0001
5	EVDS091396A1	0.0000	0.0187	0.0002	0.0000	0.0000	0.0014	0.2185	0.0000	0.0198	0.0822	0.0990	0.5382	0.0111	0.0089	0.0006	0.0012	0.0001	0.0001

†	User Sample ID	Ag_2O	Al_2O_3	Am_2O_3	As_2O_3	BaO	BeO	CaO	CdO	Cr_2O_3	Fe_2O_3	K_2O	MgO	Na_2O	NiO	PbO	PuO_2	TlO_x	U_3O_8
5	EVDS091396A2	0.0000	0.0198	0.0002	0.0000	0.0000	0.0030	0.2343	0.0000	0.0199	0.0891	0.1079	0.5036	0.0105	0.0094	0.0005	0.0014	0.0001	0.0001
5	EVDS092596A1	0.0000	0.0117	0.0002	0.0000	0.0000	0.0019	0.2606	0.0000	0.0162	0.1020	0.0525	0.5387	0.0051	0.0086	0.0006	0.0017	0.0001	0.0001
5	EVDS092596A2	0.0000	0.0155	0.0002	0.0000	0.0000	0.0028	0.2146	0.0000	0.0206	0.0889	0.0799	0.5567	0.0078	0.0105	0.0006	0.0016	0.0001	0.0001
5	EVDS100496A1	0.0000	0.0106	0.0002	0.0000	0.0001	0.0018	0.2288	0.0000	0.0164	0.0668	0.0529	0.6042	0.0060	0.0095	0.0007	0.0019	0.0001	0.0001
5	EVDS100496A2	0.0000	0.0109	0.0002	0.0000	0.0001	0.0019	0.2541	0.0000	0.0189	0.0752	0.0576	0.5626	0.0064	0.0091	0.0007	0.0023	0.0001	0.0001
5	EVDS101096A2	0.0000	0.0101	0.0002	0.0000	0.0000	0.0007	0.2894	0.0000	0.0145	0.0563	0.0623	0.5540	0.0027	0.0076	0.0002	0.0018	0.0001	0.0001
5	EVDS101096A3	0.0000	0.0109	0.0002	0.0000	0.0000	0.0006	0.3090	0.0000	0.0147	0.0554	0.0700	0.5267	0.0027	0.0074	0.0002	0.0019	0.0001	0.0001
5	EVDS101096A1	0.0000	0.0121	0.0002	0.0000	0.0000	0.0010	0.2767	0.0001	0.0187	0.0825	0.0794	0.5124	0.0037	0.0105	0.0003	0.0021	0.0001	0.0001
5	EVDS102296A1	0.0000	0.0164	0.0003	0.0000	0.0001	0.0016	0.2594	0.0004	0.0231	0.0970	0.1089	0.4724	0.0054	0.0115	0.0005	0.0027	0.0001	0.0001
5	EVDS102396A1	0.0000	0.0380	0.0002	0.0000	0.0001	0.0010	0.2927	0.0002	0.0129	0.0565	0.0728	0.5088	0.0075	0.0065	0.0004	0.0022	0.0001	0.0001
5	EVDS102396A2	0.0000	0.0303	0.0002	0.0000	0.0001	0.0010	0.3164	0.0002	0.0135	0.0587	0.0834	0.4821	0.0050	0.0065	0.0002	0.0022	0.0001	0.0001
5	EVDS102496A1	0.0000	0.0414	0.0002	0.0000	0.0001	0.0008	0.3068	0.0001	0.0124	0.0549	0.0576	0.5124	0.0045	0.0063	0.0002	0.0021	0.0001	0.0001
5	EVDS012297B1	0.0000	0.0308	0.0001	0.0000	0.0000	0.0001	0.1669	0.0000	0.0032	0.0146	0.1349	0.6460	0.0006	0.0017	0.0008	0.0002	0.0001	0.0001
5	EVDS032797B2	0.0000	0.0286	0.0013	0.0001	0.0000	0.0000	0.1125	0.0000	0.0288	0.1173	0.3361	0.3266	0.0219	0.0209	0.0030	0.0020	0.0004	0.0004
5	EVDS040197B1	0.0000	0.0289	0.0012	0.0001	0.0000	0.0000	0.1117	0.0000	0.0259	0.1087	0.3207	0.3573	0.0205	0.0194	0.0027	0.0022	0.0003	0.0003
5	EVDS040197B2	0.0000	0.0295	0.0013	0.0001	0.0000	0.0000	0.1078	0.0000	0.0282	0.1141	0.3315	0.3422	0.0204	0.0193	0.0028	0.0022	0.0003	0.0003
5	EVDS040197B3	0.0000	0.0276	0.0012	0.0001	0.0000	0.0000	0.0979	0.0000	0.0261	0.1079	0.3305	0.3640	0.0203	0.0192	0.0025	0.0021	0.0003	0.0003
5	EVDS040197B4	0.0000	0.0289	0.0012	0.0001	0.0000	0.0000	0.1006	0.0000	0.0273	0.1049	0.3118	0.3815	0.0194	0.0183	0.0031	0.0022	0.0003	0.0003
5	EVDS040297B2	0.0000	0.0114	0.0001	0.0000	0.0000	0.0000	0.1131	0.0000	0.0046	0.0193	0.0189	0.8262	0.0006	0.0031	0.0002	0.0023	0.0001	0.0001
5	EVDS040297B1	0.0000	0.0128	0.0001	0.0000	0.0000	0.0000	0.1116	0.0000	0.0062	0.0251	0.0243	0.8113	0.0011	0.0043	0.0003	0.0024	0.0001	0.0001
5	EVDS040497B1	0.0000	0.0025	0.0001	0.0000	0.0000	0.0002	0.0371	0.0000	0.0038	0.0142	0.0110	0.9257	0.0021	0.0025	0.0001	0.0005	0.0001	0.0001
5	EVDS040497B2	0.0000	0.0057	0.0001	0.0000	0.0000	0.0004	0.0674	0.0000	0.0068	0.0272	0.0280	0.8545	0.0044	0.0038	0.0003	0.0013	0.0001	0.0001

†Waste types: 1 - hot distillate (HD), 2 - oxalate filtrate (OX), 3 - lean residue (LR), 4 - ATLAS (ATL), 5 - dissolution (DS), and 6 - chloride (CL)

Appendix 2

Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks

WRITTEN ENGINEERING ASSESSMENT/CERTIFICATION FOR THE VITRIFICATION UNIT SLAB TANKS

TECHNICAL AREA 55
LOS ALAMOS NATIONAL LABORATORY

ASSESSMENT CERTIFICATION

I certify under penalty of law that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

2/23/00

2/23/00
Date

Darren Meadows, P.E.
Consulting Engineer
IT Corporation
New Mexico Registered Professional Engineer No. 13876
Expires: December 31, 2000

WRITTEN ENGINEERING ASSESSMENT/CERTIFICATION FOR THE VITRIFICATION UNIT SLAB TANKS

TECHNICAL AREA 55
LOS ALAMOS NATIONAL LABORATORY

The information in this engineering assessment is provided to meet the requirements of the New Mexico Administrative Code, Title 20, Chapter 4, Part 1 (20 NMAC 4.1), Subpart V, 264.192(a), revised January 1, 1997 [1-1-97], attesting that the vitrification unit slab tanks and ancillary equipment are adequately designed and will have sufficient structural integrity and compatibility with the waste to be stored to ensure that they will not collapse, rupture, or fail.

This written assessment and certification addresses the following requirements as they pertain to the vitrification unit slab tanks and includes the standards which must be complied with by the tank fabricator. These requirements include design standards to which the vitrification unit slab tanks and ancillary equipment will be constructed, hazardous characteristics of the waste to be stored, corrosion protection provided, excessive load protection provided to underground tank components, and adequacy of the support and foundation design.

The information for this assessment is based upon a completed design package, "Final Design Report for the DP Surety Vitrification System" from Idaho National Engineering and Environmental Laboratory (INEEL) (INEEL, 2000) and design drawings dated February 2000, prepared by Lockheed Martin. The design package describes the vitrification unit slab tanks and associated ancillary equipment to be installed at Technical Area (TA) 55, Building 4 (TA-55-4), Room 434A. It includes the physical dimensions of the vitrification unit slab tanks, the materials of construction, the location of ancillary equipment, and definition of the support system.

Vitrification Unit Slab Tanks Design Standards [20 NMAC 4.1, Subpart V, 264.192(a)(1)]

The vitrification unit slab tanks will consist of two slab tanks located in Room 434A, which is located within Room 401, at TA-55-4. Each tank will have a capacity of approximately 125 liters and will be approximately 24 inches (in.) long, 4 in. wide, and 82.5 in. high. The vitrification unit slab tanks will be parallel piped and constructed of 316L stainless steel plates, seal welded into a vacuum tight containment structure. Each slab tank will be reinforced with steel tubes, which will connect the interior opposite sides of the tank on 6-in. centers to prevent the tank wall from bulging outward. The

bottom of each slab tank will incorporate a 15 degree slope to mitigate plating and facilitate complete draining.

The primary containment welds for each slab tank will be vacuum tight in accordance with the American Society of Mechanical Engineers "ASME Boiler and Pressure Vessel Codes, Section VIII" (ASME, 1998) (hereinafter referred to as ASME BPVC Section VIII), Division 1, Subsection B, Part UW-19. All penetrations into the shell of the tanks will be designed and fabricated to ensure vacuum tightness and will comply with ASME BPVC Section VIII, Division 1. However, an ASME stamp will not be required for the vitrification unit slab tanks because they will not be operated as pressurized vessels. The vitrification unit slab tanks will be oriented vertically and an air sparge will be inserted in each tank to agitate the waste. The connections to the tank will be via standard weld neck flanges. Each tank will be vented to the facility-process vent system when waste is being pumped to the vitrification unit. Feed to the tanks will be accomplished with remote control valves and a feed pump. Sight and electronic liquid-level indicators will be mounted on the side of each slab tank for spill and overfill protection.

Piping and Ancillary Equipment Design Standards [20 NMAC 4.1, Subpart V, 264.192(a)(1)]
The vitrification unit slab tanks will be connected to three system headers (for feed, ventilation, and vacuum) by a manifold that is constructed of seamless, 316L stainless steel and meets the chemical and physical characteristics given in American Society for Testing and Materials (ASTM) "A312-Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes" (ASTM,1995), hereinafter referred to as ASTM A312 for Grade TP316L. This piping will match the existing system intake and transfer piping of 0.75-in., Schedule 40 pipe. It will meet the requirements of ASME "B31.3-Process Piping" (ASME, 1996a) for Normal Fluid Service for a design pressure of 15 pounds per square inch and design temperature of 10 degrees Fahrenheit. All piping connections will be via flanged and gasketed connections and will be provided in accordance with ASME "B16.5-Pipe Flanges and Flanged Fittings" (ASME, 1996b). The flanges will be forged from stainless steel and will meet the requirements of ASTM "A182-Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings and Valves, and Parts for High-Temperature Service" (ASTM, 1997) for Grade F316L. Gaskets will be sized for 0.75-in., Schedule 40, 150# raised-face flanges.

The vitrification unit slab tanks will be equipped with a vacuum trap that is designed to collect any mists or carryover liquid that might accumulate in the vacuum or vent lines. The vacuum trap will be constructed of Schedule 40, seamless stainless steel pipe, with an outer diameter of

approximately 6.25 in., and that meets the chemical and physical characteristics given in ASTM A312 for Grade TP316L. The vacuum trap will be equipped with a sight glass for local level indication for spill and overfill protection and will normally be empty. A float device will be located inside the vacuum trap and will plug the outlet pipe if the liquid reaches a level where it can overflow from the trap.

Hazardous Characteristics of the Waste [20 NMAC 4.1, Subpart V, 264.192(a)(2)]
The vitrification unit slab tanks will be used to store mixed transuranic waste solutions prior to treatment in the vitrification unit. These waste solutions are generated as evaporator bottoms and generally consist of concentrated nitric acid saturated with salts and metals. This waste typically exhibits the hazardous characteristics of toxicity (for metals) and corrosivity.

Corrosion Protection Measures [20 NMAC 4.1, Subpart V, 264.192(a)(3)]
The vitrification unit slab tanks and associated ancillary equipment will not be subject to the requirements of 20 NMAC 4.1, Subpart V, 264.192(a)(3) [1-1-97], for new tank components in which the external metal shell will be in contact with soil or water. The vitrification unit slab tanks and associated ancillary equipment will be located inside TA-55-4 and will not be in contact with soil or water. The vitrification unit slab tanks and associated ancillary equipment will be constructed of 316L stainless steel and will meet the chemical and physical characteristics given in ASTM A312 for Grade TP316L. The tanks will be corrosion resistant and compatible with the liquid waste to be stored in them.

Underground Storage Tank Requirements [20 NMAC 4.1, Subpart V, 264.192(a)(4)]
The vitrification unit slab tanks will not be subject to the requirements of 20 NMAC 4.1, Subpart V, 264.192(a)(4) [1-1-97], which requires a determination of the design or operational measures that will protect underground storage tanks from potential damage by vehicular traffic. The vitrification unit slab tanks and ancillary equipment will be aboveground and located inside TA-55-4.

Foundation and Tank Support Design Standards [20 NMAC 4.1, Subpart V, 264.192(a)(5)]
The vitrification unit slab tanks and associated ancillary equipment will be bolted to the 10-in. thick concrete floor and 14-in. thick south wall of TA-55-4, Room 434A. The floor provides a foundation that will maintain the load of the tank component when full. The concrete floor and ceiling were constructed to conform to the building code requirements of the American Concrete Institute (ACI) "318-Building Code Requirements for Structural Concrete and Commentary" (ACI, 1995) for

reinforced concrete. The reinforcing steel was detailed and fabricated in accordance with ACI "315-Details and Detailing of Concrete Reinforcement" (ACI, 1992). The design construction and tolerance of the framework around the concrete is in accordance with ACI "347-Guide to Formwork for Concrete" (ACI, 1994).

Each of the vitrification unit slab tanks will be mounted to the wall by two 316L stainless steel mounting plates that are approximately 5 in. long, 5 in. wide, and 0.25 in. thick and meet the requirements of ASTM "A240-Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels" (ASTM, 1998a). The mounting plates will be welded to a 304 stainless steel beam that is approximately 3 in. long, 2.4 in. wide, and 0.25 in. thick and meets the requirements of ASTM "A276-Standard Specification for Stainless Steel Bars and Shapes" (ASTM, 1998b), and the beam will be welded to the tank. The bottom of each tank will be welded to three Schedule 40, 316L stainless steel pipes that will be approximately 2.5 in. in diameter. These pipes will be welded to a single 316L stainless steel mounting plate, approximately 24 in. long, 4.3 in. wide, and 0.4 in. thick, that is bolted to the floor. The vitrification unit slab tanks will not operate under pressure; therefore, excessive stress due to expansion and contraction are not anticipated. The vitrification unit slab tanks will not be located within a saturated zone or seismic fault zone and will be within a building, so frost heave effects are not expected.

References

ACI, 1995 and all approved updates, "318-Building Code Requirements for Structural Concrete and Commentary," American Concrete Institute, Detroit, Michigan.

ACI, 1994 and all approved updates, "347-Guide to Formwork for Concrete," American Concrete Institute, Detroit, Michigan.

ACI, 1992 and all approved updates, "315-Details and Detailing of Concrete Reinforcement," American Concrete Institute, Detroit, Michigan.

ASME, 1998 and all approved updates, "ASME Boiler and Pressure Vessel Codes, Section VIII," American Society of Mechanical Engineers, New York, New York.

ASME, 1996a and all approved updates, "B31.3-Process Piping," American Society of Mechanical Engineers, New York, New York.

ASME, 1996b and all approved updates, "B16.5-Pipe Flanges and Flanged Fittings," American Society of Mechanical Engineers, New York, New York.

ASTM, 1998a and all approved updates, "A240-Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels," American Society for Testing and Materials, Philadelphia, Pennsylvania.

ASTM, 1998b and all approved updates, "A276-Standard Specification for Stainless Steel Bars and Shapes," American Society for Testing and Materials, Philadelphia, Pennsylvania.

ASTM, 1997 and all approved updates, "A182-Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings and Valves, and Parts for High-Temperature Service," American Society for Testing and Materials, Philadelphia, Pennsylvania.

ASTM, 1995 and all approved updates, "A312-Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes," American Society for Testing and Materials, Philadelphia, Pennsylvania.

INEEL, 2000, "Final Design Report for the DP Surety Vitrification System," Idaho National Engineering and Environmental Laboratory, Chemical and Environmental Engineering Department, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

WRITTEN ENGINEERING ASSESSMENT/CERTIFICATION FOR THE VITRIFICATION UNIT SLAB TANKS

TECHNICAL AREA 55
LOS ALAMOS NATIONAL LABORATORY

TANK DESIGN CERTIFICATION

STATEMENT OF TANK DESIGN ADEQUACY:

I have reviewed the design for the vitrification unit slab tanks to be constructed at Technical Area 55, Building 4, Room 401/434A, and found the design to be adequate and to have sufficient structural integrity and compatibility with the waste stored to ensure that the vitrification unit slab tanks will not collapse, rupture, or fail.

^SEISMIC RKBlandford 2/18/00

CERTIFICATION:

I certify under penalty of law that I have examined and am familiar with the information submitted in the sections entitled "Vitrification Unit Slab Tanks Design Standards" and "Piping and Ancillary Equipment Design Standards" of the Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks. The information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Robert K. Blandford

Name: Robert K. Blandford
Title: Advisory Engineer
Company: Bechtel BWXT
Registered Professional Engineer No. 3741
State: Idaho
Expires: November 30, 2000

REGISTERED PROFESSIONAL ENGINEER 3741 ROBERT K. BLANDFORD IDAHO

2/18/00
Date

WRITTEN ENGINEERING ASSESSMENT/CERTIFICATION FOR THE VITRIFICATION UNIT SLAB TANKS

TECHNICAL AREA 55
LOS ALAMOS NATIONAL LABORATORY

FOUNDATION DESIGN CERTIFICATION

STATEMENT OF TANK SUPPORT DESIGN ADEQUACY:

I have reviewed the design for the tank supports for the vitrification unit slab tanks to be constructed at Technical Area 55, Building 4, Room 401/434A, and found the design to be adequate and to have sufficient structural integrity to ensure that the tank supports will not collapse or fail.

CERTIFICATION:

I certify under penalty of law that I have examined and am familiar with the information submitted in the section entitled "Foundation and Tank Support Design Standards" of the Written Engineering Assessment/Certification for the Vitrification Unit Slab Tanks. The information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

REGISTERED PROFESSIONAL ENGINEER 3741 ROBERT K. BLANDFORD STATE OF IDAHO

Name: Robert K. Blandford
Title: Advisory Engineer
Company: Bechtel BWXT
Registered Professional Engineer No. 3741
State: Idaho
Expires: November 30, 2000

2/19/00
Date