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Preliminary Closure Plan for the Immobilized Low-Activity Waste Disposal Facility

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Abstract: This document describes the preliminary plans for closure of the Immobilized Low-Activity Waste (ILAW) disposal facility to be built by the Office of River Protection at the Hanford site in southeastern Washington. The facility will provide near-surface disposal of up to 204,000 cubic meters of ILAW in engineered trenches with modified RCRA Subtitle C closure barriers.

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Preliminary Closure Plan for the Immobilized Low-Activity Waste Disposal Facility

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

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EXECUTIVE SUMMARY

The Office of River Protection (ORP) has a mission for the environmental remediation of the Hanford Site via retrieval, pretreatment, immobilization, interim storage, and disposal of the high-level radioactive tank waste stored at the Hanford Site. During pretreatment, the waste will yield a low-activity waste (LAW) stream that subsequently will be immobilized by the Waste Treatment Contractor (WTC). The immobilized low-activity waste (ILAW) packages will be disposed of on Site in remote-handled waste (RHW) trenches. These are *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant landfills (i.e., double-lined trenches with leachate drainage system). Following ILAW emplacement an engineered barrier will be installed as a cover cap over each RHW trench to minimize maintenance and ensure long-term stability of the ILAW.

This document is a preliminary closure plan that addresses the closure activities of the proposed onsite facility to be used for the disposal of ILAW. It is a companion document to the facility's performance assessment (PA) (Mann et al. 1998) and provides critical design features and future conditions needed to conduct the PA. The PA provides the DOE with a reasonable expectation that the ILAW disposal will meet the radiological performance objectives established in DOE-M-435.1-1.

This closure plan is written in accordance with the *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Closure Plans*, dated November 10, 1999. It is a living document that will be updated throughout the operational life of the disposal site with specific information about the disposed-of ILAW and partial closure of disposal units, and other activities necessary to achieve the facility's final closed state. The Closure Plan was prepared at this time because the disposal authorization statement (DAS) requires it to be issued within a year of issuance of the DAS (i.e., before October 25, 2000).

This closure plan applies to the RHW trench disposal facility being planned to accommodate ILAW disposal for both Phase 1 and Phase 2 waste immobilization operation at the Hanford Site. The major advantages of the RHW trench are low cost and flexible capacity. The RHW trench is similar in concept to the existing Hanford Site Radioactive Mixed Waste Burial Trench. The disposal site is projected to consist of six RHW trenches, each approximately 80 m wide by 260 m long by up to 10 m deep. Each trench will contain three layers of ILAW packages separated vertically by 1 m of soil.

Revision of the Project W-520 Conceptual Design using the RHW trench concept instead of underground concrete vaults is currently scheduled to begin in October 2000 and be completed by September 2001. Advanced conceptual design is scheduled to begin in October 2001 and be completed by September 2002. Detailed design is scheduled to begin in October 2002 with construction scheduled for completion in July 2006. Operations is scheduled to begin in March 2008 and end in 2018 followed by closure of the first trench. Next, five additional RHW trenches of a similar design will be constructed in sequence. After being built, each trench will be filled with ILAW packages and a final closure cap installed. The last RHW trench is expected to be closed in 2034.

Post-closure monitoring of the six RHW trenches will continue to ensure that the ILAW is safely isolated and contamination is prevented from reaching the public and the environment. The duration of monitoring will be assessed at each permit review and renewal.

The Hanford Site burial ground design and operating practices are a historically proven, cost-effective, and regulatory-compliant approach to solid-mixed-waste disposal. An ILAW disposal architecture based on these practices should possess equally attractive attributes.

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TERMS

ALARA	as low as reasonably achievable
ASTM	American Society for Testing and Materials
BBI	best-basis inventory
BHI	Bechtel Hanford, Incorporated
CA	composite analysis
CD	conceptual design
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1981</i>
CFR	<i>Code of Federal Regulations</i>
CHG	CH2M HILL Hanford Group, Inc.
D&D	decontamination and decommissioning
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DQO	data quality objectives
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERC	Environmental Restoration Contractor
ETF	Effluent Treatment Facility
FSAR	final safety analysis report
HDW	Hanford defined waste
HLW	high-level waste
HMS	Hanford Meteorological Station
HSFUWG	Hanford Site Future Uses Working Group
HSSWAC	Hanford Site Solid Waste Acceptance Criteria
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
LAW	low-activity waste
LLW	low-level waste
NEPA	<i>National Environmental Policy Act of 1969</i>

NRC	U.S. Nuclear Regulatory Commission
OEА	Office of External Affairs
ORP	Office of River Protection
OSHA	Occupational Safety and Health Administration
PA	performance assessment
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PSER	preliminary safety evaluation report
QA	quality assurance
QAPP	Quality Assurance Program Plan
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RHW	remote-handled waste
RL	United States Department of Energy, Richland Office
RMW	radioactive mixed waste
RPP	River Protection Project
SST	single-shell tank
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TRU	transuranic
TWRS	Tank Waste Remediation System
WAC	<i>Washington Administrative Code</i>
WBS	work breakdown structure
WHC	Westinghouse Hanford Company
WTC	waste treatment contractor
WTP	waste treatment plant

DEFINITIONS

NOTE: Some definitions are adapted from the U.S. Nuclear Regulatory Commission (NRC) (10 *Code of Federal Regulations* [CFR] 61) and the U. S. Department of Energy (DOE) requirements.

Active maintenance. Any significant remedial activity needed during the period of institutional control to maintain a reasonable assurance that the performance objectives in 40 CFR 61.41 and 40 CFR 61.42 are met. Such active maintenance includes ongoing activities such as the pumping and treatment of water from a disposal unit or one-time measures such as replacement of a disposal unit cover. Active maintenance does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, minor repair of disposal unit covers, and general disposal site upkeep such as mowing grass.

Becquerel (Bq). The International System (SI) unit for activity of radioactive material. One becquerel is that quantity of radioactive material in which one atom is transformed per second or undergoes one disintegration per second (d/s).

Buffer zone. A portion of the disposal site that is controlled by the licensee and lies under the disposal units and between the disposal units and the Site boundary.

Closure. See site closure and stabilization.

Closure plans. Indicate how each DOE storage, treatment, and disposal facility will be closed on termination of operations to ensure that the public and environment will be protected. Closure plans shall be reviewed and approved (DOE O 435.1).

Composite analysis. An analysis of all sources of radioactive material that may interact with the disposal facility. The composite analysis provides a reasonable expectation that long-term impacts from the disposal facility and other sources will be acceptable. Composite analyses shall be prepared and submitted to DOE Headquarters for review and approval (DOE O 435.1).

Curie. A unit of radioactivity. The amount of any radionuclide that undergoes exactly 3.7×10^{10} disintegrations per second.

Disposal. The isolation of radioactive waste from the biosphere inhabited by man and containing his food chains by emplacement in a land disposal facility.

Disposal site. That portion of a land disposal facility used to dispose of waste. It consists of disposal units and a buffer zone.

Disposal unit. A discrete portion of the disposal site into which waste is placed for disposal. For near-surface disposal, the disposal unit usually is a trench.

Engineered barrier. A constructed structure or device intended to improve the land disposal facility's ability to meet the performance objective set forth in 10 CFR 61, Subpart C.

Gray (Gy). SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

Hazardous waste. That waste designated as hazardous by U.S. Environmental Protection Agency regulations in 40 CFR Part 261.

Inadvertent intruder. Any person who might occupy the disposal site after closure and engage in normal activities, such as farming, constructing dwellings, or other pursuits in which the person might unknowingly be exposed to radiation from the waste.

Intruder barrier. A depth of cover over the waste sufficient to inhibit contact with waste and help ensure that radiation exposures to an inadvertent intruder will meet the performance objectives set forth in 10 CFR 61, Subpart C, or engineered structures that provide equivalent protection to the inadvertent intruder.

Land disposal facility. The land, buildings, structures, and equipment intended to be used for the disposal of radioactive waste.

Low-activity waste. That secondary waste stream derived from the contents of the high-level waste tanks after separation of most of the radionuclides. Low-activity waste is the portion classified by the U.S. Nuclear Regulatory Commission (NRC) as waste incidental to reprocessing. The onsite disposal facility for low-activity waste shall meet the low-level waste requirements for disposal in accordance with DOE M 435.1-1.

Low-level waste. Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in Section 11e.(2) of the *Atomic Energy Act of 1954*, as amended), or naturally occurring radioactive material.

Mixed waste. Waste that contains both source, special nuclear, or byproduct material subject to the *Atomic Energy Act of 1954*, as amended, and a hazardous component subject to the *Resource Conservation and Recovery Act of 1976*.

Monitoring. Observing and making measurements to provide data to evaluate the performance and characteristics of the disposal site.

Near-surface disposal facility. A land disposal facility in which radioactive waste is disposed of in or within the upper 30 meters of the surface of the earth.

Package. An immobilized low-activity waste (ILAW) metal container 2.3-m high, 1.22-m diameter with a volume of 2.55 m³ that is filled on the average with 6.0 MT of waste glass (at a density of 2.66 MT/m³) and filler materials and having minimal void space.

Performance Assessment. A site-specific low-level waste disposal facility radiological performance assessment that provides a reasonable expectation of compliance with the performance objectives in Section 3.C.(4) of this chapter shall be prepared and submitted to Headquarters for review and approval. (DOE O 435.1)

Rad. A unit of absorbed radiation dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joule per kilogram (0.01 gray).

Rem. A unit of dose equivalent. Dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, a distribution factor, and any other necessary modifying factor (1 rem = 0.01 sievert).

Sievert (Sv). SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

Site closure and stabilization. Those actions taken on completion of operations that prepare the disposal site for custodial care and that ensure that the disposal site will remain stable and will not need ongoing active maintenance.

Surveillance. Observation of the disposal site for purposes of visually detecting the need for maintenance or custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.

Waste Acceptance Criteria. Ensure that the design and operating bases of each treatment, storage, and disposal facility are met. Waste acceptance criteria shall be prepared and submitted to ORP for review and approval (DOE O 435.1).

Waste Treatment Contractor (WTC). The waste treatment contractor is a primary contractor for the River Protection Project and is responsible for design, construction, and operation of the waste immobilization facility (HNF-IP-0842, Volume X, *Business*, Section 1.2, Rev. 3a). The WTC operates the waste treatment plant (WTP).

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PRELIMINARY CLOSURE PLAN FOR THE IMMOBILIZED LOW-ACTIVITY WASTE DISPOSAL FACILITY

1.0 INTRODUCTION

The Hanford Site consists of 1450 km² of shrub steppe, sand, and sagebrush located near the Columbia River in southeastern Washington State. The Hanford Site is managed by the U.S. Department of Energy (DOE), the successor agency to the U.S. Atomic Energy Commission (AEC). As a plutonium production complex, the Hanford Site played a pivotal role in the nation's defense for more than 50 years beginning in the 1940's with the construction of the Site as part of the Manhattan Project. Much of the byproduct nuclear materials created by the operations at the Hanford Site have been contained in underground waste storage tanks.

The DOE, through the Office of River Protection (ORP), created the River Protection Project (RPP) (formerly the Tank Waste Remediation System [TWRS] Project) as part of the program for environmental remediation of the Hanford Site. The RPP mission (Acree 1998) is retrieval, pretreatment, immobilization, interim storage, and disposal of the high-level radioactive tank waste and associated incidental low-activity waste (LAW) stored at the Hanford Site, followed by tank closure.

The treatment of tank waste will be performed by a waste treatment contractor (WTC). The CH2M HILL Hanford Group, Inc. (CHG), has been contracted by DOE for work scope that includes receipt of immobilized low-activity waste (ILAW) from the WTC, safe transportation of the waste to the onsite disposal facility, and final disposal and closure monitoring.

Radioactive waste management for the ILAW storage and disposal facility is implemented in accordance with DOE O 435.1, *Radioactive Waste Management*, and DOE M 435.1-1, *Radioactive Waste Management Manual*. The DOE order requires that a closure plan be prepared, reviewed, and approved as part of implementing low-level waste (LLW) disposal. The layout of this closure plan follows the *Format and Content Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Closure Plans*, dated November 10, 1999.

The DOE, in response to a Defense Nuclear Facilities Safety Board (DNFSB) review (Napolitano et al. 1994) of its radioactive waste management policy, has outlined a more strategic role for closure planning and performance assessment (PA) work in concert with the disposal facility's design work. For example, the format guide for DOE M 435.1-1 states that a conceptual design for final closure should be presented in the preliminary closure plan.

1.1 PURPOSE AND SCOPE

The purpose of this document is to provide the technical basis for defining critical design features and future conditions needed to conduct the PA. This document also satisfies the DOE M 435.1-1 requirement that a preliminary closure plan shall be submitted to Headquarters for review with the PA and composite analysis. The PA provides the DOE with a reasonable expectation that the ILAW disposal will meet the radiological performance objectives established in DOE-M-435.1-1.

The current classification of ILAW as a mixed waste makes it subject to the RCRA requirement of 40 CFR 264.112(a) that requires a written closure plan. Because the requirement for closure plans in DOE M 435.1-1 is identical to the RCRA requirement, this document and its updates will meet the RCRA requirement for the written closure and post-closure plans.

This closure plan describes the disposal facility characteristics and the technical approach that will be employed to ensure the long-term stability of the waste and minimize the need for active maintenance following closure. It is a living document that is updated throughout the operational life of the facility with specific information about the waste being disposed of, partial closure of disposal units, and other information necessary to achieve the facility's final closed state.

This document covers the preliminary closure planning for the ILAW disposal facility on the Hanford Site. Establishing the subject disposal facility and implementing disposal services and performing closure activities are the responsibility of the Immobilized Tank Waste Program, Element TW09 in the Hanford Site work breakdown structure (WBS).

1.2 BACKGROUND

During the 1980's the preferred conceptual method for treating LAW from underground tanks at the Hanford Site was by immobilization using grout as the waste form. Five vaults were designed and built during the period from 1983 to 1989 to support the LAW grout disposal program. One vault was used for grout disposal. In the early 1990's, as a result of concerns with the adequacy of disposal of LAW using grout to immobilize the waste, the grout project was terminated. The four remaining grout vaults remain unused.

The concerns about the adequacy of grout disposal involved the ability of grout to adequately inhibit contaminants leaching from the grouted waste and the ability to safely retrieve the waste from the grout vaults in the future, if retrieval became necessary for some reason. After LLW treatment options were reevaluated, a vitrified waste form was adopted as the proposed approach. The DOE issued a record of decision documenting the selection of a "Phased Implementation" alternative for retrieving and immobilizing the high-level tank waste stored at the Hanford Site.

In 1996, the DOE began a two-phase program to contract for commercial teams to provide waste treatment and immobilization services. Phase 1, the initial production phase, is being conducted in two sequential stages, with Phase 1A already completed and Phase 1B in progress. Phase 1A concentrated on design proposals; Phase 1B is focused on maturing the design for the DOE-selected technologies. Phase 1B will be a multi-year application of these treatment and immobilization technologies using waste feed prepared from approximately 25 percent by volume of the present TWRS tank waste inventory (DOE 1998). Phase 2 is the full production phase when the majority of the waste will be treated.

Different waste treatment scenarios have been modeled using complex engineering tools and detailed current data on tank waste compositions and quantities. The results of these comprehensive analyses, documented in *Tank Farm Contractor Operation and Utilization Plan* (Kirkbride et al. 2000), provides increased assurance that a credible plan, with a reasonable

chance of success, has been devised and can be implemented for tank waste retrieval and disposal. The following subsections describe the LAW treatment, an estimation of the quantity of ILAW that will be generated, and the disposal authorization for the ILAW disposal facility. The treated LAW feed will be vitrified and filled into stainless steel cylindrical containers (1.22 m in diameter by 2.3 m high) that will be sealed and disposed of on Site (modification 12 of DOE 1998). The sealed ILAW container is referred to as a package and has a volume of 2.55 m³.

1.2.1 Low-Activity Waste Treatment and Immobilization

Figure 1-1 provides a program logic flow diagram for the ILAW processing. LAW will be obtained by pretreatment processing of the high-level waste (HLW) currently in the underground tanks. The waste from selected tanks will be retrieved following a staging plan, and subsequently separated into LAW and HLW fractions. The LAW feed (the tank waste to be fed to the WTP) will be treated by the WTP to remove nearly all of the cesium isotopes and much of the ⁹⁹Tc and strontium, which will be processed separately into immobilized high-level waste (IHLW). Separations requirements for these radionuclides have not been explicitly specified. Instead, they have been translated into objective product requirements that are more stringent than NRC Class C waste (10 CFR 61), namely

- ⁹⁰Sr may not be more than 20 Ci/m³ in the ILAW
- ¹³⁷Cs may not be more than 3 Ci/m³ in the ILAW
- ⁹⁹Tc may not be more than 0.1 Ci/m³ in the ILAW.

The WTP also will remove the transuranic (TRU) elements to meet the requirements for burial of Class C waste. The waste remaining after separations, termed LAW, will be mixed with glass formers and vitrified in a glass melter. When the mixture cools, the resulting ILAW is highly effective in inhibiting the leaching of contaminants and is suitable for onsite disposal. The ILAW quantity to be disposed of depends on the pretreatment processes that the WTP uses.

The LAW feed has been categorized into compositional envelopes A, B, and C based on the best-basis inventory (BBI) of the waste stored in the underground tanks (Kupfer et al. 1999). This approach provides increased assurances about the range of waste compositions that the WTP will be required to treat and immobilize, allows demonstration of different waste processing capabilities of the contractor's facilities, and enhances flexibility in deciding how to deliver the waste.

The steps involved in processing tank waste vary from tank to tank. The waste processing activities are modeled for each tank by the Hanford Tank Waste Operation Simulator model yielding the quantity of LAW glass that will be generated. Waste loading is defined as the percent by weight of waste in the final waste form. It can be gauged by the amount of sodium present in the LAW feed that ends up as the oxide (Na₂O) in the glass. The estimate of the amount of LAW glass is therefore based on the sodium oxide (Na₂O) in the glass.

Figure 1-1 Immobilized Low-Activity Waste Disposal Program Flow Diagram

If the minimum waste loadings proposed by the draft RFP of 14 wt%, 5 wt%, and 10 wt% Na₂O are assumed for envelopes A, B, and C, respectively, during Phase 1, and a 20 wt% Na₂O is assumed for Phase 2, it is expected that 73,500 ILAW packages will be generated. This case assumes that the impact of sulfate on the Phase 2 ILAW glass is mitigated, thereby allowing higher waste loadings (Kirkbride et al. 2000). In the event that the impact of sulfate on ILAW glass is not mitigated for Phase 2, a sensitivity case in Kirkbride et al. (2000) indicates that 99,000 ILAW packages would be made. The ILAW package will contain 90 percent (minimum) by volume of ILAW glass. The package also will be topped off with an optional filler material of sand or glass that will leave less than 5 percent void space in the sealed package.

1.2.2 Expected Number of ILAW Packages

An estimate of the expected number of ILAW packages is needed to plan the size and configuration of the disposal facility. Depending on the waste loading achievable and periodic revisions made to the BBI data, the number of ILAW packages expected can change considerably. As shown in Section 1.2.1, depending on the assumptions made in the immobilization step in Phase 1 and 2, the number of packages varied from 73,500 to 99,000. For estimating the disposal site capacity needed for all the ILAW expected, an intermediate round figure of 80,000 packages is used. This figure will be updated when new data become available. The packages, containing LAW components immobilized within a glass matrix, are cleaned to remove smearable contamination then transported to the disposal facility.

Several studies were performed to evaluate alternative methods of ILAW disposal with an aim to develop the best and most cost-effective option. As part of the contingency planning for Phase 1 ILAW disposal, the DOE had elected to have about 19,200 m³ of the initial production of Phase 1 ILAW stored in the four unused concrete grout vaults located east of the Hanford Site 200 East Area boundary. Because the vaults would require expensive physical modification (e.g., installation of roof access and a building with a remotely operated crane over each vault) to make them suitable for storing or disposing of ILAW, a study was performed to evaluate an alternative remote-handled waste (RHW) trench concept (Shah 1999) with the capability to remotely handle cylindrical ILAW packages with a contact dose rate up to 1000 mR/hr. A cost savings of \$250 M was projected if the ILAW was disposed of in RHW trenches instead of the originally planned concrete vaults. Consequently, ORP was directed to rebaseline the ILAW disposal program by changing the scope of Project W-520, ILAW Disposal Facility, to incorporate the RHW trench concept (Taylor 1999a).

As indicated in Kirkbride et al. (2000), 13,500 ILAW packages that will be generated during Phase 1 of tank waste treatment. One reasonable approach is to design a RHW trench to hold all the ILAW generated in Phase 1. At 13,500 packages per trench, 6 trenches would be needed to hold the resulting 80,000 packages.

1.2.3 Disposal Authorization for Low-Activity Waste Disposal Facility

Before construction of the LAW disposal facility, DOE M 435.1-1 requires that a disposal authorization statement (DAS) be obtained. A DAS is documentation authorizing operation of a low-level waste disposal facility resulting from the DOE Headquarters review and acceptance of

the facility's performance assessment, composite analysis, and other information and evaluations. The DAS constitutes approval of the performance assessment and composite analysis, authorizes operation of the facility, and includes the conditions the disposal facility must meet. The DAS for ILAW at the Hanford Site was issued by DOE-Headquarters, Environmental Management Office (EM-35), in October 1999 and is included as Appendix A to this document.

1.3 GENERAL FACILITY DESCRIPTION

This description applies to the RHW trench disposal facility that has been adopted as the new baseline (Taylor 1999a) for disposal of ILAW packages. The location chosen for the RHW trench disposal facility is in the 200 East Area of the Hanford Site. The Hanford Site is owned by the U.S. Government, and its use currently is controlled by the DOE. Land surrounding the Hanford Site is primarily used for agriculture. The present land use in the facilities on Site is "Industrial-Exclusive" (DOE/EIS 1999). More descriptive information on the disposal facility is given in Section 2.1.

The RHW trench is a RCRA-compliant landfill that includes a double-lined trench with a leachate drainage and collection system. The RHW trench design is expected to be similar to that of the radioactive mixed waste (RMW) land disposal facility designed and built under the Hanford Site Solid Waste Program. The planned disposal site will consist of six RHW trenches. The preconceptual layout of the six ILAW disposal trenches is shown in Figure 1-2. The disposal facility also includes an operations support building. The dimensions of an individual trench are shown in Figure 1-3. The inner rectangle represents the bottom of the trench (200 m x 20 m) and the outer rectangle indicates the top of the trench.

The estimate of the number of trenches is based on a production of 80,000 packages of ILAW. Consolidation of the six trenches into one extremely large trench was considered and rejected for the following reasons:

The first RHW trench was sized to match the Phase 1 ILAW disposal requirements.

The design and operation phase of each subsequent trench will span 6 to 8 years.

Each trench, at 80 m by 260 m, is itself very large and will require large amounts of dirt to be moved. Consolidating the trenches will make this task unwieldy.

The cover cap with a 2 percent grade will make the center point of the cap several meters above existing grade.

The configuration of the trenches presented here will be reviewed during the conceptual design of the ILAW disposal facility.

Figure 1-2. Proposed Remote-Handled Waste Trench Arrangement.

Figure 1-3. Dimensions of Remote-Handled Waste Trenches.

1.3.1 Remote-Handled Trench Description

A preliminary design concept of the RHW trench is shown in Figure 1-4 and summarized in Table 1-1. The base of each trench is 20 m by 200 m and the sides have a gradual slope of 1 m rise for every 3 m run so each successive layer can be increased in length and width and can accommodate more packages than the layer below it. Overall dimensions of each trench are approximately 80 m wide by 260 m long by up to 10 m deep. The 10 m depth excludes the liner system, the cover cap thickness, and the 2 percent slope of the final grade. Each trench will contain three layers of ILAW waste packages separated vertically by 1 m of soil. A layer consists of multiple cells as shown in Figure 1-4. Each cell contains an array of packages spanning the length of the trench. The array consists of staggered columns of packages to maximize packing efficiency. The calculation for the number of packages in a cell is shown in Table 1-1 for the RHW trench model depicted in Figure 1-4. This layout of the RHW trench is subject to change. For example, the capacity of the trench can be increased by reducing the space between the cells. The size and layout of the cells will be optimized and updated during the conceptual design (CD) phase scheduled to begin in fiscal year (FY) 2001.

EPA regulations (40 CFR 264) involve requirements for installing two or more liners and a leachate collection and removal system for ILAW disposal trenches (NRC and EPA 1987) (see Appendix C). Using the RMW burial trench design as an example, the bottom of each RHW trench will likely contain a primary and secondary flexible membrane liner (FML) made of a 60 mil thick high-density polyethylene (HDPE) sheet (Figure 1-5). Specifications for this liner system can be found in WHC-S-045, *Material Specifications and Construction Requirements for the Radioactive Mixed Waste Land Disposal Facility, Non-Drag-off, Project W-025* (WHC 1994).

The primary and secondary drainage gravel layers shown in Figure 1-5 are for the two drainage collection systems associated with the RCRA-compliant disposal facilities (see Appendix C). A perforated collection pipe located under the primary gravel layer allows collected liquids to drain to a sump at either end of the trench for sampling and removal. Both the primary and secondary liners lie atop an admix layer. The admix layers are 0.5 m and 1 m thick, respectively. Admix consists of bentonite-enriched soil that is mixed, moisture conditioned, placed, compacted, and trimmed to form the soil liner before placing the FML. The secondary admix layer offers backup containment of contaminants in the unlikely event that the secondary liner fails catastrophically. The topmost layer at the bottom of each trench consists of an operations layer whose composition can be tailored to meet special needs. For example, the operations layer could contain soil mixed with crushed concrete to sequester uranium ions that might be released from the disposed-of waste. The first layer of ILAW containers is placed directly on the operations layer.

The tops of the packages must be at least 5 m below the surface of the trench (DOE/RL 1996). The liner, as depicted in Figure 1-4, extends well past the last package. Details of how the liner is routed as it approaches the RCRA Subtitle C Barrier and the original grade at the edge of the trench will be determined during development of the conceptual and final designs along with cost optimization.

Table 1-1. Package Configuration in Trench.

Layer	Cells per Layer	Cell Size	Packages per Cell*	Packages per Layer	Layer Size
1	2	8 m x 200 m	6 x 150.5	1,806	20 m x 200 m
2	3	11 m x 218 m	(9 x 164.5)+ 0.5	4,443	38 m x 218 m
3	5	9 m x 236 m	8 x 178	7,120	56 m x 236 m
TOTAL				13,369	

* The fractional numbers account for a partial staggered row of packages that can be added depending on the length of the cell.

1.3.1.1 Leachate Collection System. Any water that might transgress the RCRA barrier either vertically or laterally will be trapped in the trench liner and leachate collection system. This system will ensure that water does not collect in the trench and create a “bathtub” effect, thus helping to prevent corrosion of the waste packages.

Figure 1-6 illustrates a typical leachate collection and removal system used in hazardous waste landfills (Kreith 1994). Perforated pipe, placed in each leachate collection channel, is used to convey the collected leachate to a sump located at the edge of the trench. The method shown for the removal of leachate from the sump involves using an inclined riser pipe located within the landfill. This method and other options will be evaluated thoroughly and appropriate design features incorporated during development of the RHW trench liner and barrier cover design.

Liquids entering the RHW trench sump will be detected by instrumentation. Leachate samples can be removed by lowering a sample collection device down the leachate riser. Leachate could be removed using a portable pump with a hose lowered down the riser pipe. The leachate will be pumped into a holding tank then transferred to the Effluent Treatment Facility (ETF) for treatment and disposal.

The amount of leachate expected will influence the holding tank size, which will be determined during the detailed design phase. The current concept is to connect the Project W-520 leachate collection tank to the 242-A Evaporator condensate sewer leading to the ETF for direct transfer of leachate using a pump. Another option is to transport the leachate to the ETF by tank truck. The leachate collection and removal system will continue to be operated until leachate is no longer detected (40 CFR 264.310).

Figure 1-4. Remote-Handled Trench Pre-Conceptual Drawing.

Figure 1-5. Remote-Handled Waste Trench Liner System.

Figure 1-6. A Typical Leachate Collection System

1.3.2 Ancillary Facilities

The ancillary facilities will consist of a control-administration building and groundwater monitoring wells. Other facilities may be determined to be necessary during the detailed design phase.

1.3.2.1 Control/Administration Building. The control-administration building is expected to be a permanent preengineered single-story building constructed of concrete tilt panels. The control-administration building will contain office areas, a control room, a heating, ventilation, and air-conditioning (HVAC) room, a conference and training room, separate men's and women's locker rooms, restrooms, a lunchroom with kitchen facilities, a shop area, a fire riser room, a switchgear room, a telecommunications room, and storage space for both operations and maintenance supplies.

The control-administration building will be provided with telephone and Hanford local area network (HLAN) service. An automatic fire suppression system (sprinkler system) will be provided along with a local low-energy fire alarm system with battery back up. This system will be capable of sending alarms and trouble signals to the Hanford Fire Department using the Sitewide fire alarm reporting system. Additional information will be included in a future update following completion of the detailed design.

1.3.2.3 Groundwater Monitoring Wells. Groundwater monitoring wells for the ILAW disposal site will be located around the ILAW disposal site. The monitoring well system will be designed in coordination with the 200 East Area system. The wells will be protected from tampering or damage by installing steel guard posts and a padlock and providing access control by Site Security. The ILAW disposal site groundwater monitoring wells will be integrated into the Hanford Sitewide monitoring network.

1.4 GENERAL CLOSURE APPROACH

ILAW RHW trench disposal facility will be closed as landfills with the waste remaining in place. Site closure will include constructing a closure cover for each trench to minimize long-term intrusion or infiltration of water. The closure cover is a Modified RCRA Subtitle C barrier (DOE/RL 1996). The closure cover consists of a topsoil layer, a lateral drainage area, and a barrier layer. The closure cover provides a minimum of 5 m of soil cover above the surface of the top of the uppermost layer of ILAW packages and extends at least 6 m beyond the surface edge of the secondary trench liner. The modified RCRA barrier has a requirement to design the low-permeability layer of the cover to have a permeability less than or equal to any natural subsoils present. Additionally, it is required that "for frost protection, the lateral drainage layer and the low-permeability asphalt layer must be located at least 75 cm below final grade." The PA takes no credit for the RCRA barrier in evaluating contaminant release.

Groundwater samples will be taken regularly to verify that no radioactive or hazardous waste is leaching from the ILAW packages. All wells will be inspected regularly to ensure proper operation. The overall condition of each well will be checked during each groundwater sampling event. Items inspected include padlocks, well casing, guard posts, and pumps. A detailed well

condition evaluation will be performed in accordance with the Hanford Site Environmental Monitoring Plan (DOE/RL 1997).

Leachate collection, sampling, and disposal activities will be initiated for each trench at the start of disposal in each trench in accordance with RCRA requirements. The time allotted for post-closure care will vary depending on the findings during post-closure monitoring. The duration of monitoring will be assessed at each permit review and renewal.

1.5 CLOSURE SCHEDULE

A preliminary schedule for ILAW disposal is presented in Figure 1-7. Shipment of the Phase 1 ILAW is scheduled to begin in December 2007 (DOE 1998, DOE 2000). The contractually specified quantity to be processed is approximately 10 percent by volume and 25 percent by total radioactivity of the RPP tank waste inventory. Phase 1 is scheduled to be completed in 2018. Phase 2 will process the remainder of the RPP tank waste inventory. Production of the Phase 2 ILAW is scheduled to begin in 2018 and be completed by 2033.

A series of disposal trenches will be built as needed and preliminary closure activities will be instituted for each trench as it is filled. When a trench is full, the final closure cap for that trench will be installed.

Project W-520 is designated for the design of the overall ILAW disposal facility. The work scope for W-520 includes designing the closure cap system for the proposed Phase 1 and Phase 2 ILAW disposal facility. Trenches for Phase 2 disposal activities will be constructed as a separate project.

Project W-520 encompasses the design and construction of the first RHW trench. This trench will be available for waste disposal in 2007. Production of ILAW packages is expected at the rate of up to 1,058 packages per year from 2008 to 2013 and up to 1,544 packages per year from 2014 to 2018. All of these ILAW packages can be accommodated in the first trench. Design and construction of the second trench is expected to begin in 2015; this trench will be ready to accept waste in October 2018. Up to five additional trenches of the same size are expected to be needed to accommodate all the ILAW to be produced from processing the waste from the Hanford Site tanks. The trenches are expected to be closed and closure caps installed sequentially at 3-year intervals starting in early 2018 and ending in 2034.

Disposal operations are expected to last for 25 years or more. Operations will continue until 2033 when the retrieval of all tank waste and production of the last ILAW package is expected to be completed.

Figure 1-7 Preliminary Schedule for ILAW Disposal

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1.6 RELATED ACTIVITIES

This section discusses Site-specific regulatory context and documentation required for ILAW disposal. It also presents information on other programs, plans, and tasks being undertaken at Hanford that have a relationship with this closure plan. Studies regarding integration of the ILAW closure activities with other 200 Area burial grounds have not been performed as of this closure plan revision but may be performed in the future. If so, the results from such studies will be incorporated in a future closure plan update.

A recent study, *Phase I Feasibility Study for the Canyon Disposition Initiative (221-U Facility)* (DOE/RL-97-11), examined six alternatives for final disposition of the Hanford Site canyon buildings (the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, U Plant, the Reduction-Oxidation (REDOX) Plant, and T Plant). The alternatives, especially entombment, presented in the study were evaluated for potential impacts on the ILAW storage facility and none were noted. The only plant of any concern was PUREX because of its proximity to the ILAW disposal site. However, the PUREX plant is far enough from the proposed ILAW site that even the largest potential burial mound presented in the study would not interfere with the ILAW disposal trenches.

1.6.1 Regulatory Requirements

In the early 1990's the DOE petitioned the NRC for a ruling on the classification for the ILAW prepared from the RPP tank waste. The NRC has conditionally approved that the proposed RPP ILAW can be disposed of as incidental waste (Paperiello 1997) subject to the following conditions:

- The "waste has been processed (or will be further processed) to remove key radionuclides to the maximum extent technically and economically practical."
- The "waste will be incorporated in a solid physical form at a concentration that does not exceed the applicable concentration limits for Class C LLW as set out in 10 CFR [Code of Federal Regulations] Part 61."
- The solid, immobilized waste will be managed, pursuant to the *Atomic Energy Act of 1954*. This requirement ensures that the performance objectives equivalent to those set out in 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," are satisfied.

This NRC waste classification decision means that the disposal of the ILAW, as prepared from double-shell tanks (DST) and single-shell tanks (SST), would not be controlled by the HLW disposal licensing authority of the NRC. This classification also enables the RPP to plan to dispose of this ILAW in shallow land disposal facilities in accordance with DOE O 435.1, *Radioactive Waste Management*. The primary requirements imposed by DOE O 435.1 and its associated manual are listed in Appendix C along with applicable EPA and NRC requirements and/or guidance.

The federal and state regulations and requirements governing the handling, storage, and disposal of toxic or hazardous waste also must be followed. Because ILAW is classified as a hazardous waste, RCRA permitting must be obtained for the ILAW disposal facility (RCRA 1976). The ILAW Part B permit must be submitted to the Washington State Department of Ecology (Ecology) in 2002 (*Hanford Federal Facility Agreement and Consent Order* [Tri-Party Agreement] milestone M-20-57) to meet the current construction schedule. There are no current plans for obtaining exemptions from RCRA for ILAW.

DOE facilities are not subject to NRC regulations and the NRC is not expected to have regulatory authority over the ILAW disposal facility at the Hanford Site in the future.

1.6.2 Performance Assessment, Composite Analysis, and Preliminary Monitoring Plan

The regulatory guidance and requirements strongly advocate an early start and an ongoing and thorough integration of the closure cap system design with that of the rest of the disposal facility system (Napolitano et al. 1994, Appendix B, Appendix C, DOE 1999a). The guidance and requirements also recommend that similar integration be performed between the overall disposal system design and the PA work.

Design concepts and preliminary evaluations have been conducted to support selection of a reference concept for the closure cap system design. This was in support of the PA work for the proposed disposal facility. The selected closure cap system uses a defense-in-depth design approach, yielding a multilayered barrier stacking system (see Section 2.2.4).

1.6.2.1 Performance Assessment. The PA examines the long-term environmental and human effects of the planned Hanford Site ILAW disposal facility to support DOE issuance of a disposal authorization statement as required by DOE O 435.1 and to support the preparation of the RCRA Part B permit as required by Ecology. The 1998 version of the ILAW PA was written using available data. DOE conditionally approved the ILAW PA (DOE 1999a) and issued a disposal authorization statement (Fiore and Frei 1999). As required by DOE (Mann 1999), the ILAW PA is being maintained. The first iteration (Mann et al. 2000) updates the 1998 ILAW PA by using site-, waste-form-, and facility-specific data (Mann and Puigh 2000). Important changes are the analysis of the RHW trench, improved groundwater calculations, and deterministic simulations of the degradation of the expected waste form. Section 3.1 compares the expected impacts with the performance objectives. The next full revision of the ILAW PA is expected in 2001.

The RHW trench concept design analyzed in Mann et al. (2000) was determined to be adequate to meet the overall performance needs of the proposed disposal facility. Mann et al. (2000) also determined that the performance of the RHW trench is superior to the concrete vault concept of ILAW disposal. Both the remote-handled waste trenches and the concrete vaults would meet the performance objectives of the ILAW performance assessment. However, degraded concrete will significantly increase the pH of the water in contact with the glass waste forms, resulting in a faster contaminant release rate (Mann et al. 2000).

The 1998 ILAW PA modeled the effects of the naturally occurring recharge rate into the disposal facility at 3 mm per year. Work at the Hanford Site supported by field lysimeter tests (Fayer

et al. 1999) shows that a Modified RCRA Subtitle C closure cap or one of similar design would meet the performance needs of the proposed disposal facility. Because the cover systems evaluated performed much better than the design goal of 0.5 mm/year, a recharge rate of 0.1 mm/year is proposed in Fayer et al. (1999) for the 2001 update of the PA. The PA also concluded that a sand-gravel capillary break-barrier, which currently is part of the planned closure design, would provide significantly improved disposal system performance at a low cost.

The capillary break-barrier consists of a layer of sand on top of a layer of gravel. In an unsaturated system, the capillary pressures are much less than atmospheric pressure. For significant quantities of water to flow into and through the coarser sublayers, the water pressure must be raised to nearly atmospheric pressure. Thus, the overlying fine soils must become nearly saturated for water pressure to approach atmospheric pressure and allow water to flow into the sublayers. Keeping the water in the fine-texture layer provides time for evaporation and transpiration to remove it. (Wing 1994).

The sloping sides of the RHW trench are lined with geotextile fabric that will impede lateral flow of moisture into the trench. The barrier cap extends a few meters beyond the outer edges of the trench, further hindering moisture migration. Potential modifications to layer dimensions and barrier components will be evaluated by the ongoing PA work (Mann et al. 1998).

1.6.2.2 Composite Analysis. The *Composite Analysis for the Low-Level Waste Disposal in the 200 Areas of the Hanford Site* (Kincaid et al. 1998) deals with the environmental impact from all waste that will be disposed of in the Central Plateau of the Hanford Site at the time of site closure. The CA was recently approved (Fiore and Frei 1999). It is a companion analysis to PAs for active and planned waste disposal and remedial investigations and feasibility studies for remediation sites. Subject to some limitations of available waste inventory data, this was a preliminary analysis to discover the long-term effects to an offsite individual from all waste present at the Hanford Site at the time of site closure. For the CA, the offsite individual resided outside the exclusive waste management area and buffer zone as defined by the Hanford Future Site Uses Working Group (HFSUWG 1992). This buffer zone is about 1 km from the present 200 Area fences. The analysis considered a 1,500-year period and reached the following conclusions:

- Significant releases from the liquid discharge sites, tank leaks, losses from tanks during tank waste recovery operations, and pre-1988 solid waste burial grounds have occurred or could occur before site closure and would be significantly separated in time from any releases from the active or planned disposal. That is, contaminants from active and planned disposal should not contact groundwater for at least 1,000 years, whereas the releases from operations already have reached groundwater or will reach groundwater in the next few hundred years.
- Peak all-pathways dose to the maximally exposed individual outside the buffer zone after site closure (assumed in 2050) was less than 6 mrem in a year. Despite high uncertainty in the inventories of past liquid discharges, tank leaks, tank losses, and pre-1988 burial grounds, this analysis indicated dose outside the buffer zone would not exceed the dose limit of 30 mrem in a year.

- Peak dose rates are highest now and will decline with time. The dose rates are still associated with remnants of the existing plumes at the time of site closure. Releases from liquid discharges, tank leaks, tank losses, and pre-1988 burial grounds will continue to enter the aquifer over the next few decades, but in general, the rate of nuclide mass releasing to the aquifer will decline from now until site closure and continue to decline.
- No releases from the RPP ILAW disposal facility are seen during the DOE regulatory period of 1,000 years or the full 1,500 years analyzed.

Future iterations of the CA will be based on a more fully consistent inventory for all post-closure waste sites including canyon buildings and associated facilities including permanent filters and the PUREX tunnels.

1.6.2.3 Preliminary Monitoring Plan. Section IV.R(3) of the manual for DOE O 435.1 requires that an environmental monitoring plan be prepared. Currently, a Sitewide monitoring plan (DOE/RL 1997) exists for the Hanford Site. The monitoring plan is updated and reissued on a 3-year cycle. Its next update is due to be issued during November 2000. The ILAW project will use the results of the Sitewide monitoring program to determine the adequacy of groundwater models. The monitoring plan contains a section that specifically addresses groundwater monitoring on the Hanford Site. The ILAW Preliminary Monitoring Plan is being written in parallel with this closure plan and will be sent to the ORP at the Hanford Site by October 2000 for approval. Monitoring will be performed in accordance with the approved plan.

A brief discussion of pertinent parts of the Monitoring Plan will be presented in a future update of this closure plan.

1.6.3 RCRA Requirements Including Permit Conditions

The RPP tank waste contains listed hazardous waste and falls under the jurisdiction of RCRA. Unless such waste is treated to the point where it no longer is considered hazardous and is "delisted" (formally removed from regulation), the RCRA requirements (40 CFR 260-268) apply. In Washington State, these federal regulations regarding waste handling and disposal are administered by Ecology under *Washington Administrative Code* (WAC) 173-303.

The permitting obligations for the operations phase of the disposal facility must be completed and satisfactorily complied with to support the closure phase, including any carry-over obligations required by the permitting. All permitting requirements for the proposed ILAW disposal facility have been addressed in a permitting plan for ILAW disposal (Deffenbaugh 1997). Future revisions of this closure plan will present detailed discussion of the interface between the closure plan and the permitting plan.

The requirements of WAC 246-247 require a Washington State-issued air quality permit. However, an exemption from this permit is possible if the disposal product or design can be qualified as a sealed source, which is expected to be the case, in accordance with the proposed DOE product acceptance requirements for the Phase 1 ILAW disposal product (DOE 1998).

1.6.4 Relevant Agreements

The Tri-Party Agreement (Ecology et al. 1996) is an agreement between DOE, the U.S. Environmental Protection Agency (EPA), and Ecology concerning the cleanup of the Hanford Site. The Tri-Party Agreement has legally enforceable milestones, some of which (the M90 series) cover the Immobilized Waste Program. Tri-Party Agreement milestones M90-00 through M90-10 and M-20-57 all pertain to the ILAW program and call for hot operation to commence by January 31, 2007. The following are the Tri-Party Agreement milestones for ILAW that remain to be met:

M-20-57	Submit ILAW disposal facility certified Part B permit application to Ecology – 8/31/02.
M-90-00	Complete acquisition of new facilities for disposal of ILAW – To be established 9 months after approval of Project Management Plan.
M-90-08	Initiate ILAW disposal facility construction – 7/31/04. (Initiation of construction occurs when the contractor commences excavation of the RCRA disposal facility.)
M-90-09-T01	Complete ILAW disposal facility detailed design – 3/30/04.
M-90-10	Initiate placement of ILAW in the disposal facility (requires retrieveability) – 1/31/07.

1.6.5 Planned or Completed *National Environmental Policy Act of 1969* Documentation

The RHW trench is a concept for a near-surface disposal unit. Existing *National Environmental Policy Act of 1969* (NEPA) documentation provides updated ILAW management activities and addresses retrievable disposal of ILAW in engineered subsurface vaults (DOE and Ecology 1996 and RL 1998). The RHW trench concept is consistent with the ILAW activities analyzed. A supplemental analysis currently is being performed to formally document this position. The estimated completion date for this supplemental analysis (number 3) is August 31, 2000.

1.6.6 Safety Analysis Report

Effective quality and environmental safety and health protection programs will be established and maintained to ensure compliance with DOE requirements in all areas of onsite ILAW transportation and RHW trench design, construction, and operation.

The final safety analysis report (FSAR) will be based on the detailed design and will be further discussed in a future update of this closure plan. The FSAR, when completed, may impose

various requirements on the design and/or operation of the facility. If these requirements also affect closure, they will be covered in a future closure plan revision.

1.6.7 Groundwater Protection Management Plan

Pacific Northwest National Laboratory (PNNL) has prepared an *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project* (Hartman et al. 1999) for the DOE. The ILAW disposal site monitoring wells will become a part of the 200 East Area groundwater monitoring effort and, as such, will be monitored under the Hanford Site monitoring plan.

The Environmental Restoration Contractor (ERC), currently Bechtel Hanford Inc. (BHI), is responsible for integrating Sitewide groundwater and vadose zone evaluations, so environmental restoration is an essential component to this plan as it relates to vadose zone issues. In conjunction with the RL Office of External Affairs (OEA), BHI is responsible for managing all communications regarding Site projects and public involvement activities that affect the vadose zone or groundwater. OEA in turn will involve the ORP Public Involvement Manager and ORP contractor support staff when their participation on vadose zone-groundwater public involvement activities is required.

The overriding theme of the RPP is that treatment and disposal of the Hanford Site's tank waste will provide the greatest protection for human health and the environment (DOE and Ecology 1996). In addition, recent confirmatory evidence of past tank leakage affecting the groundwater reinforces the need to remove pumpable liquids from SSTs as soon as possible and retrieve waste from the tanks and convert it to a form that will not pose further threats to human health and the environment. According to HNF-EP-0182-143 (Hanlon 2000) the SSTs still contain 17.6 ML of pumpable liquid, all of which is expected to be removed by September 2003.

1.7 SUMMARY OF KEY ASSUMPTIONS

The assumptions listed in this section relate in part to the provisional status of the classification of Hanford Site tank waste by the NRC and the ILAW regulation by RCRA. Other assumptions are based on tank waste inventory determination and characterization, and ILAW specifications including waste loading.

1.7.1 Regulatory Classification Status of Hanford Tank Wastes

It is assumed that the NRC will continue to classify the ILAW as incidental waste. This is based on a conditional agreement that the LAW portion of the Hanford Site tank waste will not be subject to NRC licensing authority (NRC 1997), as discussed in Section 1.6.1.

Under the current EPA "mixture" and "derived-from" rules, the ILAW would continue to be managed as a RCRA-regulated mixed (hazardous and radioactive) waste because it is derived from tank waste that contains listed hazardous constituents. Although the vitrification process would result in a product that complies with the land disposal restrictions, the ILAW disposal facility would still have to meet the requirements of a RCRA Class I hazardous waste landfill, including double liners, leachate collection systems, leak detection, and closure and post-closure

monitoring systems. This is reflected in Tri-Party Agreement milestone M-20-57, "Submit ILAW Disposal Facility Part B Application to Ecology by August 30, 2002."

1.7.2 ILAW Specifications

The ILAW disposal program will receive only ILAW packages from the WTP. The planning and implementation of Phase 1 and 2 ILAW disposal are based on the following assumptions regarding this topic:

- The Phase 1 WTC will meet or exceed all of the DOE ILAW acceptance requirements as defined in the current contract (DOE 1998).
- The Phase 2 ILAW acceptance requirements are assumed to be the same as the Phase 1 requirements.

1.7.3 Quantity of ILAW from Phase 1 and Phase 2

The current estimates for ILAW package volumes are about 34,000 m³ for Phase 1 and 170,000 m³ for Phase 2. This provides the basis for the disposal system capacity requirement of up to 204,000 m³. These assumptions are based on the waste loading specifications for the WTC, 90 percent fill of the packages, and the tank characterization provided by the best basis inventory (Kupfer et al. 1999).

The ILAW program and project are maintaining close contact with the present WTC. Such interactions include developing separation and immobilization technologies. These interactions will continue and it is recognized that even after the WTC makes the initial selection of technologies, changes may be made to improve and optimize the processes.

2.0 DISPOSAL FACILITY CHARACTERISTICS

This section presents information on the Hanford Site, especially the area surrounding the ILAW disposal facility. For additional information on site characteristics the reader should refer to the PA (Mann et al. 1998) where this topic is discussed in greater detail. The facility characteristics section includes a detailed description of the cover barrier selected for the RHW trenches and emphasizes those features important for the long-term performance of the disposal system. Section 2.3 describes the LAW and ILAW characteristics, provides data on their inventory, and helps to form a basis for understanding the approach to closure of the disposal facility.

2.1 SITE CHARACTERISTICS

This section describes the regional and local environment in which the ILAW disposal facility will be located. The following sections describe the disposal site, along with the climatological, geological, and geographical conditions of the 200 Area plateau.

2.1.1 Geography and Demography

Extensive research has been done on the Hanford Site geography. However, this section will cover only the characteristics that will be used to model the ILAW disposal facility's long-term performance. More complete descriptions will be referenced whenever applicable.

2.1.1.1 Disposal Site Location. The Hanford Site is an area of approximately 1450 km² located in south-central Washington State. The site for the disposal facility is located on the Hanford Central Plateau in the 200 East Area within the Hanford Site boundary shown in Figure 2-1. The location of the disposal site relative to the 200 East Area is shown in Figure 2-2.

The Hanford Central Plateau is approximately 198 m to 229 m above mean sea level. The major features of regional geography are the nearby rivers (Columbia and Yakima) and mountains (Saddle Mountains and Umtanum to the north, Cascade Mountains to the west, Yakima Ridge to the southwest, and Rattlesnake Ridge to the south). The Columbia River, which forms the eastern boundary of the developed areas of the Hanford Site, is an important source of water and hydroelectric power for the region. Other important rivers near the Hanford Site are the Yakima River to the southwest and the Snake River to the east. The Cascade Mountains, which are about 160 km (100 mi.) to the west, have an important influence on the climate of the area in their rain shadow, which includes the Hanford Site.

Figure 2-1. 200 East Area Relative to the Hanford Site and Washington State.

Figure 2-2. Remote-Handled Waste Trench Location within the 200 East Area.

2.1.1.2 Disposal Site Description. All Phase 1 and 2 ILAW will be disposed of in six RHW trenches that will be designed and built on the Hanford Site specifically for this purpose. The site selected for the new disposal facility is on a plateau in the southeastern quadrant of the 200 East Area and is shown in Figure 2-2. The DOE has approved the choice of this site for ILAW disposal (Rutherford 1997). The selected disposal site consists of approximately 36.4 ha of vacant and uncontaminated land located just southwest of the PUREX facility (Short 1995 and Reidel 1997).

2.1.1.3 Demography. Figure 2-3 shows the Hanford Site location within Washington State and its relationship to the northern border region of Oregon State. It also identifies the major cities in the region; Seattle, Portland, and Spokane, each of which is over 160 km from the Hanford Site.

In general, the Hanford Site is more than 160 km from any major city (e.g., a city with more than 100,000 inhabitants). The Site is surrounded by a rural-type population distribution associated mostly with agricultural activities. The Tri-Cities (Kennewick, Pasco, and Richland), less than 40 km from the Site, are the nearest communities of significant size (e.g., more than 20,000 inhabitants). These three cities are grouped together along the Columbia River a few miles downstream of the Site to the southeast of the Site boundary. Several smaller communities lie within 80 km of the Site.

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Figure 2-3. Major Population Centers Surrounding the Hanford Site.

Figure 2-4 illustrates the region around the Site and notation on the population distribution within that region (i.e., for towns and cities and the total for each county). See DOE (1998b) for more detailed discussion of this topic.

Note: If population not listed, less than 1,000

HMS = Hanford Meteorological Station

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Figure 2-4. Population Distribution

2.1.1.4 Uses of Adjacent Lands. In 1992, the Hanford Future Site Uses Working Group (HFSUWG) was charged with determining potential future uses of the various parts of the Hanford Site. This group consisted of local, state, and federal officials, representatives of affected Indian tribes and agricultural and labor organizations, as well as members of environmental and other special interest groups. The efforts of the HFSUWG form the basis of the Hanford Site Comprehensive Land-Use Plan Environmental Impact Statements (DOE/EIS 1999).

The 200 East Area is presently classified as “Industrial-Exclusive” (DOE/EIS 1999). This land-use designation would preserve DOE control of the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and waste treatment, storage, and disposal facilities. If the Industrial-Exclusive use designation is maintained, records of past activities (particularly the disposal of nuclear materials) are likely to be kept. In addition, in an industrial area, liquid discharges to the ground would be highly regulated and kept small.

The Central Plateau and the Horse Heaven Hills, both south of the Hanford Site, are near, but at a significantly higher elevation than the Columbia River. Although the amount of irrigation is increasing at certain locations, comparatively little irrigation occurs in the Horse Heaven Hills because of the relatively high energy cost of bringing water to the surface. Dry-land farming continues to be the main use for the land in the Horse Heaven Hills.

East of the Central Plateau, across the Columbia River, irrigated farming is extremely common. The water, however, does not come from the nearby stretches of the Columbia River. The water comes from the Columbia Basin Project, which derives its water from the Grand Coulee Dam, over 322 km (200 mi.) upstream of the Hanford Site. The water is gravity-fed to the farms. The regional geography makes such a water delivery system unlikely for the Central Plateau.

The area south of the Central Plateau is a combination of residential, commercial, and industrial zones. Agriculture is practiced on the north side of the Waluke Slope. Finally, west of the Plateau is the Fitzner/Eberhardt Arid Lands Ecology Reserve, a nature preserve.

2.1.1.4.1 Hanford Reach National Monument. The newly designated Hanford Reach National Monument is located in south-central Washington State along the Columbia River. It encompasses approximately 81,000 ha (200,000 acres) of public land within the borders of DOE’s Hanford Site. The monument, whose lands have been or are being cleaned up to meet EPA and State requirements, acts as a buffer around a portion of the Hanford Site.

Because the 200 East Area is located outside the area that has been designated a national monument, and because the ILAW disposal facility is located within the 200 East Area, the national monument designation has no effect on the ILAW disposal facility.

2.1.1.5 Socioeconomics. The major employers in the Tri-Cities area since 1970 have been the DOE and the Hanford Site contractors; Energy Northwest (formerly the Washington Public Power Supply System), which operates a nuclear power plant; farms; and a large food processing industry; plus several smaller industrial operations. Other than DOE activities, agriculture and food processing are the dominant industries. The socioeconomics of the area surrounding the Hanford Site are described more fully in Cushing (1995).

The land use around the Hanford Site varies from urban to rural. Most of the land south of the Site is urban, including the Tri-Cities, while much of the land to the north and east is irrigated cropland. Most of the irrigation water comes from the Bureau of Reclamation's Columbia Basin Project, which uses Grand Coulee Dam as the primary water source. The land to the west of the Hanford Site is used for irrigated agriculture near the Yakima River and dry-land farming at the higher elevations.

The area rivers are used primarily as sources of irrigation, drinking water, and recreation. Recent designation of a portion of the Hanford Site as a national monument will have no effect on the proposed ILAW disposal facility.

2.1.2 Meteorology and Climatology

The following paragraphs briefly describe this topic. Detailed information on the Hanford Site's climate is available in the PA analysis (Mann et al. 1998) and in the design requirements document for Project W-520 (Ashworth and Burbank 1998). The Project W-520 design requirements mandate that the disposal facility design must be capable of operating at or near the temperatures and conditions provided by the Hanford Meteorological Station (HMS).

Long-term stability of the disposed-of waste could be affected by wind or water erosion of the RHW trench barriers. Regional temperatures and wind conditions that will need to be considered in the closure design have been discussed in Sections 2.1.2.1 through 2.1.2.4.

2.1.2.1 Precipitation. Precipitation is one of the most important weather characteristics that must be recognized in siting and designing the ILAW disposal facility. The Hanford Site sits within the Pasco Basin, which is characterized as a semi-arid region because of its low annual precipitation levels. The basin receives only 16 cm (6.3 in.) of precipitation annually on average, with about 44 percent occurring during the winter months (Mann et al. 1998). Characterization of the precipitation records for the HMS, which is considered similar to the proposed disposal site in the 200 East Area, is as follows:

“Historical data indicate that over roughly 80 years, the annual precipitation varied from a low of 8 cm (3.1 in.) to a high of 30 cm (11.8 in.). Precipitation of 4 cm (1.56 in.) in 24 hours can be expected to occur once every 25 years. Total annual snowfall has varied from 0.8 cm to 110 cm (0.31 to 43.3 in.), with an average annual snowfall of 34 cm (13.4 in.). The largest depth of snow on the ground at one time was 62 cm (24.4 in.). Small hail, with diameters from 5 to 10 mm (0.2 to 0.4 in.), has been recorded at the HMS, with 2 days of hail being the most in any one year.”

2.1.2.2 Temperature. Temperature is another important weather characteristic that must be recognized in designing and closing the ILAW disposal facility. Atmospheric temperature directly affects evapotranspiration that is a factor in determining the amount of precipitation that infiltrates into the RHW barrier layers. The temperature conditions for the Hanford Site and the 200 Area Plateau range from extremely cold during the winter months to extremely warm during the summer months. This can result in local temperatures of below -18°C (0°F), during some winter months, especially at night. During some summer months, the temperature during the day

can exceed 40°C (104°F). Characterization of the HMS temperature records for the Project W 520 design requirements are as follows (Ashworth and Burbank 1998):

“The mean surface air temperature averages approximately 12°C (53°F) at the HMS. July tends to be the warmest month of the year with temperatures averaging 25 and 33 °C (61 and 92 °F) respectively. The highest temperature ever recorded on the Site is 46 °C (115 °F). January is the coolest month of the year with an average temperature of -2 °C (29 °F). The lowest temperature ever recorded on the Site was -33 °C (-27 °F).”

2.1.2.3 Wind. The wind conditions are another Site weather characteristic that must be considered in designing and closing the ILAW disposal facility. The wind conditions can vary considerably on the 200 Area Plateau throughout the year. The monthly average is about 10 km/h (6 mi/h) during the winter and 15 km/h (9 mi/h) during the summer. Wind speeds at specific times, especially during summer storm activity, can reach many times this average level. The greatest peak gust was 130 km/h (81 mi/h), recorded at 15 m above ground at the Hanford Meteorological Station. Extrapolations based on 35 years of observation indicate a return period of about 200 years for a peak gust in excess of 145 km/h (90 mi/h) at 15 m above ground level (Mann et al. 1998). Erosion by wind action also is a potential degradation that the disposal facility design work must address.

2.1.2.4 Relative Humidity. The seasonal variation in the relative humidity is considerable according to the records of the HMS. This weather characteristic is one that must be recognized in designing the barrier system for the RHW trench disposal facility. Like temperature, humidity has a direct effect on the evapotranspiration rate and therefore indirectly has a bearing on the moisture-recharge rate. The Ashworth and Burbank (1998) characterization of these relative humidity records for the Project W-520 design requirements is as follows:

“The annual mean relative humidity recorded at the HMS is approximately 54 percent with the highest monthly average relative humidity (80 percent) occurring in December and lowest average monthly relative humidity (32 percent) occurring in July. Daily relative humidity can change 20 to 30 percent between early morning and late afternoon, except in the winter months when the changes are less pronounced.”

2.1.3 Ecology

This section summarizes the ecology of the Hanford Site, emphasizing plant and animal activities that may affect exposure pathways. The primary impact would be through roots penetrating and animals burrowing through barriers into a disposal facility. Secondly, the types of plants and animals and their density can affect net groundwater recharge, which is greatly influenced by surface vegetation and burrowing. Cushing (1995) details both the terrestrial and aquatic ecology of the Hanford Site and presents extensive listings of plant and animal species. This section will consider only terrestrial ecological effects because the proposed immobilized low-activity tank waste disposal facility sites are not located near significant aquatic ecological systems.

The Hanford Site consists of mostly undeveloped land. Only about 6 percent of the Site is occupied by chemical processing facilities, shut-down nuclear reactors, and supporting facilities. Most of the Hanford Site has not experienced tillage or agricultural grazing since the early 1940's.

The Hanford Site is characterized as a shrub-steppe environment. This environment contains numerous plant and animal species adapted to the region's semiarid climate. Because of the aridity and low water-holding capacity of the soils, the productivity of both plants and animals is relatively low.

2.1.3.1 Flora. The dominant plants on the Hanford Site have changed over time. In the early 1800's, before settlement and agricultural activities, the dominant plants were big sagebrush and perennial bunchgrass. Agriculture opened the area to invasion by alien plants, predominantly cheatgrass. Today, cheatgrass dominates fields and rangeland that were cultivated 50 years ago. The dominant plants on the Hanford Central Plateau are big sagebrush, rabbitbrush, cheatgrass, Russian thistle, and Sandberg's bluegrass, with cheatgrass providing half the plant cover. Root penetration to depths of over 3 m has not been demonstrated in the 200 Areas. Rabbitbrush roots have been found only at a depth of 2.4 m (8 ft) near the 200 Areas.

2.1.3.2 Fauna. A variety of birds and mammals inhabit the Hanford Site. The most abundant nesting birds of the shrub-steppe at the Hanford Site are the horned lark and western meadowlark. Significant populations of chukar and grey partridge inhabit the Site. The most abundant mammals of the Hanford Site are mice, ground squirrels, gophers, voles, and cottontail rabbits. Larger animals include mule deer and elk. The coyote is the principal mammalian predator on the Hanford Site.

2.1.4 Geology

The physical geology of the 200 East Area, along with much of the Hanford Site, is a layered structure. The geologic structure is composed of multiple layers of sediments, which range from sand, silt, volcanic ash, and clay to coarse gravels and cobbles and conglomerates that overlay thick layers of basaltic lava. The layers of sediments often are heterogeneous in their composition and discontinuous in their physical structure. Some of these sediment layers were deposited during glacier-age floods thousands of years ago. The geology of the near-surface region typically has been modified by the weather, especially the wind; dune and sheet sands cover much of the area.

2.1.4.1 Regional and Site-Specific Geology and Topography. The proposed ILAW disposal facility is on the Hanford Central Plateau, a Pleistocene flood bar most commonly referred to as the 200 Areas Plateau, near the center of the Hanford Site. The Hanford Central Plateau is approximately 198 m (650 ft) to 229 m (750 ft) above mean sea level. The plateau decreases in elevation to the north, northwest, and east toward the Columbia River. It also decreases to the south, although not as abruptly as it does to the east. The plateau escarpments have elevation changes of 15 to 30 m (50 to 100 ft).

2.1.4.1.1 Site Geologic History. The Hanford Site is situated within the Pasco Basin of south-central Washington State. The Pasco Basin is one of many topographic depressions located

within the Columbia Intermontane Province, a broad basin located between the Cascade Range and the Rocky Mountains. The sediment package of the Pasco Basin consists of a relatively thick sequence of fluvial, lacustrine, and glacio-fluvial sediments over the past several million years. The Columbia Intermontane Province is the product of Miocene continental flood basalt volcanism, and regional deformation that occurred over the past 17.5 million years. The Pasco Basin is bounded on the north by the Saddle Mountains; on the west by the Hog Ranch-Nanen Ridge anticline; on the south by Rattlesnake Mountain and the Horse Heaven Hills; and on the east by the Palouse Slope.

The physical geography of the Hanford Site is dominated by the low-relief plains of the Pasco Basin and anticlinal ridges of the Yakima Folds physiographic region. The surface topography of the Hanford Site is the result of the following events:

- Uplift of anticlinal ridges
- Pleistocene cataclysmic flooding
- Holocene eolian activity.

Uplift of the ridges began in the Miocene epoch (starting about 17 million years ago) and continues to the present. This uplift is occurring on geologic time scales (i.e., over tens of millions of years). The uplift is not incorporated into the conceptual model of the ILAW disposal facility, which addresses a time scale of tens of thousands of years (Mann et al. 1998).

2.1.4.1.2 Flooding. Glacier-related flooding has had a major impact on the physical geography of the region. Cataclysmic flooding occurred when ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington. The last major flood occurred about 13,000 years ago, during the late Pleistocene epoch. Interconnected flood channels, giant current ripples, and giant floor bars are among the landforms created by the floods. These formations resulted in heterogeneous and discontinuous characteristics for sediments ranging in size from silts to coarse gravels. These sediments yield a wide range of vadose zone hydraulic properties.

2.1.4.1.3 Landslides. Landslides have had a limited effect on the Hanford Site's geography. Previous landslide activity in the area is generally limited to the White Bluffs area east of the Hanford Site and the Rattlesnake Hills south of the Site. No landslide activity is observed in the Hanford Central Plateau.

2.1.4.1.4 Sand Dune Activity. The location of the Hanford Site in an intermontane basin helps maintain a semiarid climate with low recharge. Eolian activity at the Hanford Site is relevant in evaluating the disposal facility because winds can cause erosion and create sand dunes and indirectly affect the rate of percolation of water into the RHW trench (Fayer et al. 1999).

The proposed ILAW Disposal Site lies along the northern margin of a giant dune field. The existence and characteristics of the dune field appear to be controlled by wind moving from west to east, down the adjacent Dry Creek and Cold Creek valleys and across the expansive Hanford Site plains toward the Columbia River. A long, stabilized dune lying in an east-west direction can be seen along the southern border of the proposed ILAW Disposal Site north of Route 4S (Figure 2-5).

The history of sand dune development in this area dates back to the last cataclysmic flood (approximately 13,000 years ago). During the Holocene Epoch (the last 11,000 years), winds have locally reworked the flood sediments. It has been estimated that sand transport was most active earlier than 4,400 years ago and the dunes stabilized thereafter. Most sand dunes on the Hanford Site are located southeast of the 200 East Area and are stabilized by vegetation. However, they have been reactivated where vegetation has been disturbed, by fire or other activity.

Figure 2-5. Aerial View of the New ILAW Disposal Site.

(The viewing direction is southeast. The 200 East Area Coal Power Plant and Water Purification Plant are in the foreground. The Existing Disposal Site, which is not shown, is 1.4 km directly east of the coal plant.)

The closest point of active dune formation to the proposed ILAW Disposal Site is approximately 3 km south of this area. Its location approximately downwind of the new disposal site, coupled with the planned closure cap vegetation layer, suggests that wind will have an insignificant effect on the percolation of water into the ILAW disposal facility in the future.

2.1.4.2 Seismology. The disposal site is in a relatively quiet seismic region. The past seismic history of the Hanford Site and surrounding area has been quite extensively characterized as part of previous Hanford Site program activities. The DOE has had a seismic monitoring network operating in and around the Site since 1969. The design basis ground motion used for design

will be obtained from the latest revision of WHC-SD-GN-ER-501, *Natural Phenomena Hazards, Hanford Site, Washington* (Conrads 1998).

2.1.4.3 Volcanic Activity. The Cascade Mountain range contains the only volcanoes in the region. The nearest of these is Mount Adams, approximately 160 km (100 mi.) away. The most active of these nearby volcanoes in recent times has been Mount St. Helens, located approximately 220 km (136 mi.) from the Site. Volcanic flows are not expected from these mountains because of their locations. The only expected effect of an eruption would be ashfall.

2.1.4.4 Other Natural Occurrences for the Site. The following paragraphs briefly describe other natural occurrences and their frequency at the Hanford Site.

2.1.4.4.1 Tornadoes. The regional weather records do not support a major concern about tornadoes being a significant occurrence and hence a threat to this disposal facility. However, the design requirements for this disposal facility require that they be designed to survive specified tornado conditions.

2.1.4.4.2 Range Fires. Fire is an event that could disrupt the performance capabilities of certain features of the disposal facility. Fire protection and prevention design must recognize this potential and account for its effects. The Hanford Site has a historical record of experiencing fires that damage or even destroy relatively large tracts of vegetation. Occasionally even some buildings have been endangered. Such fires have occurred from either lightning strikes or human activities; most commonly along the public highway that runs northwest to southeast across the southwestern edge of the Hanford Site. Such fires could pose a threat to certain engineered features of the disposal facility, particularly during the operations period. In particular, fires could pose a threat to engineered vegetation features incorporated into the outermost layer of the closure cap barrier system. Such vegetation destruction could increase the risk of wind and/or water erosion. The design needs to ensure that the barrier performance would not be unacceptably degraded by fire.

2.1.5 Hydrology

The following paragraphs briefly describe the known hydrology conditions for the Hanford Site and most specifically the 200 Area Plateau.

2.1.5.1 Surface Water. Although large rivers are near the Hanford Site, no significant long-term surface water features are near the disposal site. Several disposal ponds, used during past fuel reprocessing activities at the Hanford Site for cooling water discharge, are near enough to the proposed disposal site that they could have an artificial influence on net contributions to the water table. However, these disposal ponds are not expected to exist when current operations end, thereby negating any effect that they may currently have.

Except for catastrophic glacial flooding, which is not expected for tens of thousands of years, no floods are expected to affect the 200 Area Plateau.

2.1.5.2 Groundwater. An unconfined aquifer exists in the lower part of the sedimentary sequence overlying the uppermost basalt flow. This relatively thin aquifer is considered the primary contaminant pathway for evaluating exposure scenarios. The aquifer intercepts infiltration from the vadose (unsaturated) zone above it, providing a pathway for water and contaminant transport to the Columbia River. The aquifer under the proposed disposal site is approximately 90 to 100 m below the surface grade (Mann et al. 1998).

The groundwater pathway is considered the most likely pathway for contaminants released from an ILAW disposal facility for the following reasons:

- Low precipitation in the Pasco Basin
- Lack of surface transport pathways near the disposal facility
- Subsurface location of the disposal facility
- Near-surface lysimeter measurements showing downward movement of water
- Samples showing the existence of radioactive contamination plumes in the groundwater because of past Hanford Site operations.

2.1.5.3 Recharge. The recharge of water into the ground at the proposed disposal site is expected to be small. This condition results primarily from the relatively low levels of annual precipitation that occur in the region of the disposal site as well as the rest of the Hanford Site. See Section 2.1.2.1 for further information about precipitation levels and Section 2.2.1 for more information regarding water infiltration.

2.1.6 Geochemistry

Hanford scientists have been studying the geochemistry of the Hanford Site vadose zone and groundwater for a long time. Little work has been done with surface water however because geochemistry plays a small role there.

The strategy has been to identify waste contaminants, pertinent geochemical conceptual release and sorption models, and available data that quantify the environment; calculate the range of sorption, solubility, and release rate variables; collect data; simulate the contaminant transport; then determine if the disposal action is acceptable given the data uncertainties.

The Hanford Site has a long history of conducting laboratory experiments to determine geochemical retardation. The results of the first experiment were reported in 1966. These experiments (see Kaplan and Serne [1995] for a summary of the experiments) are normally performed by passing a solution, typical of the contaminant leachant, through relevant sediments from Hanford Site soils.

The data used in the PA (Mann et al. 1998) are based primarily on Kaplan and Serne(1995) and Kaplan et al. (1995). Subsequent research was documented in Kaplan et al. (1996). A review of this research suggests that moisture dependency may be more complex than previously thought (Kaplan et al. 1996) and that colloidal transport will not be a concern at the Hanford Site (McGraw and Kaplan 1997). The most recent geochemical data are presented in Kaplan and

Serne (2000). In this data package the solubility of contaminants is approximated as a simplified parameter known as "solution concentration limits." The distribution coefficient (K_d) and the solution concentration limit for each contaminant will be fed into subsurface flow and transport codes for the ILAW 2001 PA. Based on the dose predictions of the 2001 PA, a more rigorous approach to contaminant solubility may need to be adopted for a subsequent PA.

2.1.7 Natural Resources

The Central Plateau of the Hanford Site has no important natural resources except industrial minerals. No major mining operations exist in the area of the Hanford Site. Oil and gas exploration have occurred in the region; however, no economically viable accumulations of either were found. Some local gravel processing is being performed in the area.

2.2 FACILITY CHARACTERISTICS

This section provides information on the engineered features of the disposal facility and their effectiveness in meeting performance standards. The topics covered are the integrity and design of the closure cap for protecting and safeguarding the ILAW against water infiltration and inadvertent intruders.

2.2.1 Water Infiltration

Water flow in the near-surface unsaturated zone at the Hanford Site is transient because of intermittent precipitation events. Transient water flow begins when water enters at the ground surface and infiltrates downward into the soil column. At some distance from the ground surface, transient effects will dampen out, and the downward-flowing water will reach a steady rate. The distance at which steady infiltration occurs is sometimes referred to as the penetration depth. Thus, the unsaturated zone essentially consists of two regions: an unsteady-flow region between the ground surface and penetration depth, and a steady flux in the lower unsaturated region is equal to the annual rate of groundwater recharge and therefore is composed of contributions not only from the most recent pulse, but from previous precipitation events as well.

The ILAW disposal facility will be situated below the penetration depth in the region of steady flow. The natural rate of moisture infiltration is approximately 3.0 mm/year (Fayer and Walters 1995). However, the natural rate of moisture infiltration will change because construction of the disposal system will destroy the natural soil-sediment profile and remove surface vegetation. To prevent or minimize infiltration, a protective surface barrier will be engineered with sediment layers and one or more capillary barriers. The closure cover proposed is a Modified RCRA Subtitle C barrier. Infiltration beyond the root zone depends on the soil-atmosphere interface where surface soils and sediments and vegetation interact with the climate. The frequency, duration, and magnitude of precipitation and runoff events in part determine the infiltration rate into the disposal facility. Other parameters are the unsaturated hydraulic properties of the surface and subsurface infiltration barriers and the surrounding soil.

2.2.2 Disposal Unit Cover Integrity

The RHW trench closure cap forms an essential part of the disposal facility. This section identifies the design features used to ensure its long-term integrity and effectiveness. As noted earlier, the NRC, EPA, and DOE each have provided guidance and/or requirements that are applicable to the ILAW onsite disposal planning and implementation. The regulatory requirements and guidance offer considerable flexibility in configuring the barriers and barrier components for an acceptable closure cap design. The closure cap system design can be tailored with respect to the characteristics of the disposal facility and the specific nature of the waste to ensure that the defined PA objectives of the disposal system are met.

2.2.2.1 Major Topical Concerns of Regulations and Guidance. The applicable regulations and guidance provide several major topical requirements for ensuring the stability and integrity of the closure cap system. The following are the major topical concerns that are the basis for the requirements:

- Failure of engineered barriers of the closure cap and the rest of disposal facility barrier system
- Subsidence of emplaced disposal product (waste) and other engineered barriers of the disposal system
- Slope stability
- Surface erosion by wind and water
- Closure cap disturbance by other meteorological events or other natural events
- Excess water infiltration (i.e., through the closure cap and/or underlying barrier system of the waste emplacement assemblage) causing percolating water to contact and interact with the waste (ILAW packages and ultimately the ILAW form)
- Intrusion into emplaced waste (ILAW) by humans, plants, or animals.

Tables 5-1, 5-2, and 5-3 in the EPA (1989) guidance document on closure cover systems provide informative examples of recommended design specifications for categories of recommended barrier types to consider in designing closure cover systems.

2.2.2.1.1 Specific Regulations and Guidance Concerning Water and Leachate Control.

Specific emphasis regarding how the design will deal with water and leachate diversion and/or collection are suggested by the NRC (10 CFR 61) and prescribed by the EPA (40 CFR 264, 40 CFR 265), and other related regulations and guidance (NRC and EPA 1987, WAC 173-303). The topical considerations of particular concern here can be summarized as follows:

- [10 CFR 61.7(b)(2)] (NRC) - The long-term stability of the waste and disposal site requires minimization of the access by water.

- [10 CFR 61.51(a)(6)] (NRC) - The disposal site should be designed to minimize to the extent practicable the contact of water with waste during storage and the contact of standing water with waste after disposal.

NOTE: This NRC guidance is particularly directed at avoiding a design/performance development of a “bathtub” effect in which the waste could become immersed in liquid within a disposal unit located below grade with a low-permeability bottom surface. This applies to the closure cover system design, as far as its performance could help avoid or mitigate such performance problems.

- [40 CFR 265.300 and 264.317] (EPA) - Requires the installation of two or more liners and a leachate collection and removal system above and between the liners to protect human health and the environment.

NOTE: Exceptions to the double liner and leachate collection system requirements are allowed if alternative design and operating practices, together with location characteristics, are demonstrated to the EPA’s regional administrator to be equally effective in preventing the migration of hazardous constituents into the groundwater or surface water (NRC/EPA 1987). This also applies to the closure cover system design, as far as its performance could affect such performance concerns.

Tables 5-1 through 5-3 in the EPA (1989) guidance document on closure cover systems provide further guidance on closure cover design regarding concerns about water drainage and diversion.

2.2.2.2 Barrier Design Selection. The principal design objective of a disposal facility for ILAW is to effectively contribute to protection of the public and the environment through effective long-term isolation of the waste material. The principal design objective for the closure system is to ensure that it transforms the facility from operational status to inactive status in a manner that ensures the disposal site's integrity and ability to continue isolating the waste. The design of a disposal site and closure system requires integration with closure plan requirements.

Detailed assessments of four surface barrier designs that constitute potential generic remedial alternatives for 200 Area waste sites were performed in a recent focused feasibility study (FFS) (DOE/RL 1996). The designs presented in this study are as follows:

- **Hanford Barrier.** Designed to provide 1,000-year isolation of waste sites containing Greater than Class C LLW, Greater than Class C mixed waste, and significant inventories of transuranic (TRU) constituents.
- **Modified RCRA Subtitle C Barrier.** Designed to provide 500-year isolation of waste sites with dangerous waste, Category 3 LLW, Category 3 low-level mixed waste, and Category 1 low-level mixed waste as defined by the *Hanford Site Solid Waste Acceptance Criteria*, (FDH 1998).
- **Standard RCRA Subtitle C Barrier.** Designed to provide 30-year isolation of dangerous waste sites.

- **Modified RCRA Subtitle D Barrier.** Designed to provide 100-year isolation of waste sites with Category 1 LLW and nonhazardous-nonradioactive solid waste.

The generic design from the FFS reflects a barrier that meets potential design criteria and can be simplified or reduced if not all the design criteria are needed for the specific site. During the site-specific evaluation, the cover design can be tailored to factor in specific location, contaminants, risk levels, etc. Figure 2-6 represents the graded approach in DOE/RL (1996) for selecting a suitable barrier design for the Hanford Site's ILAW disposal facility. Decision gates numbered in the figure correspond to the following questions.

1. Does the disposal facility contain significant inventories of TRU constituents?
2. Does the disposal facility contain LLW with greater-than-Class C activity (i.e., does waste activity exceed Category 3 limits)?
3. Does the disposal facility contain waste regulated as dangerous waste?
4. Does the disposal facility contain LLW with Category 3 activity?
5. Does the disposal facility contain LLW with Category 1 activity?
6. Is only nonradiological, nonhazardous solid waste present?

The following decisions show the logic path through Figure 2-6 used for this closure system.

- The ILAW disposal facility will not contain significant quantities of TRU constituents nor LLW with greater-than-Class C activity.
- The proposed disposal facility may contain waste regulated as dangerous waste, but this may not apply if the waste is delisted.
- However, the ILAW disposal facility will contain LLW with Category 3 activity.

Based on this information, the Modified RCRA Subtitle C Barrier is identified as the appropriate surface barrier design for the ILAW disposal facility.

Figure 2-6. Barrier Decision Logic.

2.2.2.3 Design Criteria. Lists of design criteria for various barrier systems were assembled in DOE/RL (1996). The set of design criteria for the Modified RCRA Subtitle C Barrier is summarized as follows:

1. Minimize moisture infiltration through the cover.
2. Design a multilayer cover of materials that are resistant to natural degradation processes.
3. Design a durable cover that needs minimal maintenance during its design life.
4. Design a cover with a functional life of 500 years.
5. Prevent plants from accessing and mobilizing contamination (i.e., prevent root penetration into the waste zone).
6. Prevent burrowing animals from accessing and mobilizing contamination.
7. Ensure that the top of the waste is at least 5 m below final grade or include appropriate design provisions to limit inadvertent human intrusion.
8. Facilitate drainage and minimize surface erosion by wind and water.
9. Design the low-permeability layer of the cover to have a permeability less than or equal to any natural subsoils present.
10. Design the cover to prevent the migration and accumulation of topsoil material within the lateral drainage layer (i.e., clogging of the lateral drainage layer).
11. For frost protection, the lateral drainage layer and the low-permeability asphalt layer must be located at least 0.75 m below final grade.

2.2.2.4 Barrier Configuration and Sizing. Current preconceptual design work on Project W-520 indicates the closure cap barrier system will be composed of a layered assemblage of different engineered barriers. Figure 2-7 is a cross-sectional elevation view of this closure cap barrier system concept. Each layer within the closure cap will be sloped with a 2-percent grade to allow runoff and minimize erosion. A barrier overhang will be used to control potential water infiltration problems at the edges of the barrier. "Barrier overhang" is the term used to describe the projection of the functional barrier surface beyond the perimeter of the waste zone. The barrier overhang will extend 2 m beyond the edge of the disposal trench. Beyond the barrier overhang, the barrier layers above the low-permeability layers will extend farther, but at a steeper slope of 3:1 (horizontal:vertical) until they reach the existing ground elevation. The grading fill layer of the barrier located underneath the low-permeability layers will extend beyond the barrier overhang as well. This layer will support the 3:1 sloped layers extending beyond the barrier overhang.

2.2.3 Structural Stability

DOE guidance (DOE 1990, DOE 1992, DOE 1999a) on stabilization and closure of disposal facilities provides listings of characteristics needed by an acceptable disposal site. The NRC, EPA, and DOE regulations and guidance (see Section 1.6.1) all impose similar requirements regarding the need for such disposal facilities to have adequate physical stability. The NRC guidance and DOE requirements are primarily performance based, while the EPA hazardous waste regulations include specific design requirements. Key concerns addressed by such requirements will be met as described in the following paragraphs.

The ILAW package is the single most important building block in ensuring the structural stability of the disposal facility. The WTC must provide the DOE with packages that conform to the contract specifications, which encompass all applicable regulatory requirements. The anticipated chemical and physical character of the ILAW is described in Section 2.3. Information on the exact contents of a package, including filler material, will be documented by the WTC and provided to the DOE. The ILAW package will contain 90 percent (minimum) by volume of ILAW glass. The package also will be topped off with an optional filler material of sand or glass that will leave less than 5 percent void space in the sealed package.

Preliminary calculations indicate that with three layers of ILAW packages in the RHW trench, the total subsidence caused by package voids will not exceed 0.3 m. The slope stability of the disposal system will not be compromised in case of subsidence, thus ensuring continued effectiveness of the Modified RCRA Subtitle C barrier (see Section 2.2.4). Water infiltration can be the single most destructive element in ILAW degradation and release of contaminants. Water infiltration is reduced considerably by the barrier and the ILAW disposal trenches are located sufficiently above the water table that groundwater contact will not occur directly.

The operational and interim closure activities (Section 3.2.1) and final closure (Section 3.2.2) minimize the potential ingress of water into the disposal facility during all phases of the disposal program. The Modified RCRA Subtitle C barrier design also provides appropriate deterrence to intrusion into the disposal facility by plants, animals, and humans and minimizes surface erosion of the engineered barrier system, including the closure system.

2.2.4 Inadvertent Intruder and RCRA Barrier Description

The combination of engineered barriers of a LLW disposal facility is a series of barrier layers whose primary purpose is to support the waste isolation function of the disposal facility. The barriers support the waste isolation function primarily by preventing and/or impeding the ingress of intruders that could degrade the ILAW and result in release of waste constituents.

The Modified RCRA Subtitle C barrier design is the baseline design for waste containing not only dangerous waste, but also Category 3 LLW. The barrier is designed to provide hydrologic protection and containment for a performance period of 500 years (DOE/RL 1996). The term "Modified" designates that this design differs in certain key aspects from the EPA's minimum technology guidance (MTG) for RCRA covers. The MTG design has a 30-year design life. No Modified RCRA Subtitle C barrier system is in use at the Hanford Site at this time.

The approximate height of the assemblage of barriers for the Modified RCRA barrier as proposed in the FFS (DOE/RL 1996) would be at least 1.7 m and consist of 8 layers including a grading fill of variable thickness. Table 2-1 provides a comprehensive summary of the essential functions and characteristics of each proposed barrier layer for that particular concept. For ILAW disposal at the Hanford Site, the initial choice of barrier materials, barrier thickness, and degree of capping barrier slope are presented in Figure 2-7, but are subject to change during design. They will be tailored to the function and performance requirements for these uppermost layers as the disposal facility design and PA work progresses.

The Modified Subtitle C RCRA barrier shown in Figure 2-7 differs from the FFS in that a second capillary break has been added. This, or a similar barrier layer system, will be built over the trenches following completion of waste emplacement, backfilling, and then temporary closure of each trench. The depth of the top of the emplaced ILAW packages will be at least 5 m.

The structure of the closure cover acts as a barrier against infiltration and intruders. The closure cover will be constructed as described in the following paragraphs:

Grading fill consisting of excavated soil will be placed over the top of each layer of ILAW packages to ensure a total depth below surface level of at least 5 m and a 2-percent slope from the center to the longer edge of each trench. A sand and gravel graded two-part filter (labeled Capillary Break # 2), consisting of 1 m of gravel topped by 1 m of sand, will be placed over the grading fill. The sand layer will be smoothed to establish a planar base surface for accurate and controlled placement of the overlying layers. A 10-cm -thick asphalt base course will be placed over the gravel. This base course will provide a stable base for placing the overlying low-permeability asphalt layer. Grade stakes are used to ensure that thicknesses and overall slopes are maintained.

The next task will be installing a water infiltration barrier. The asphaltic concrete mixture will be specially formulated to produce a minimum hydraulic conductivity and will be applied 15 cm thick. A spray-applied asphalt then will be applied over the layer to seal any voids or defects in the surface. This layer will function as a low-permeability barrier as well as a human-intrusion barrier. The asphalt layer also is expected to serve as a highly effective deterrent to intrusion by plant roots and burrowing animals. The 2-percent slope will carry infiltrated water to the layer edges where it will enter the surrounding soil.

Next, a 15 cm-thick layer of drainage gravel will be laid down. The function of this layer will be to allow moisture that reaches this layer to laterally migrate to the barrier edge.

The next task will be installing the second two-part graded filter layer (labeled Capillary Break #1). The lower layer will be a 15 cm-thick gravel filter layer. The gravel in this layer will be sized to be compatible with the lateral drainage gravel layer below and the sand filter layer above to prevent fine-textured sand from moving downward. Once the gravel filter layer is installed, a 15 cm-thick sand filter layer will be installed. The purpose of these two layers is to prevent topsoil particles from moving downward and clogging the lateral drainage layer. They also serve as another capillary break to divert infiltration.

After the filter layers are installed, a 50 cm thick layer of compacted topsoil will be installed. This layer (Layer 2 in Figure 2-7) will supplement the moisture storage capacity of the layer to be installed above it. The material used for the topsoil will be McGee Ranch silt loam without pea gravel. This layer of topsoil will be compacted, perhaps up to 85 percent of optimum dry density.

Another 50 cm-thick layer of topsoil will be installed next. This layer will contain McGee Ranch silt loam, along with 15-wt. percent pea gravel, 2.4 mm to 9.5 mm in diameter, mixed uniformly. The topsoil mixture will be placed at a bulk density of approximately 1.46 g/cm^3 , which would be conducive to plant growth. The pea gravel is designed to minimize wind erosion of the silt loam without significantly affecting its moisture retention capabilities. Construction quality control will be conducted throughout installation of each layer to ensure that the appropriate slopes are maintained and that the desired compaction is attained. Appropriate quality assurance records will be kept during construction and will be made part of the permanent facility logbook.

Next, the ground will be prepared for planting and fertilized. Once this is complete, the ground will be seeded with mixed perennial grasses and planted with shrubs and sagebrush.

A fence will surround the perimeter of the ILAW disposal facility. This fence will prevent medium to large animals from accessing the cover. The cover will be inspected quarterly for signs of burrowing animals. Small animals are not expected to penetrate the low-permeability components of the cover. Typical small-animal species living on the Hanford Site tend to live in the upper 1.2 m of earth.

2.2.4.1 Conformance To Design Criteria. This section shows how the Modified RCRA Subtitle C Barrier conforms to the design criteria listed in Section 2.2.2.3 and the PA (see Appendix D). In Table 2-1, each design criterion has been addressed individually; the criteria and corresponding conformance attributes are listed in adjacent columns. Layer numbers referenced in the table refer to the corresponding cover layers shown in Figure 2-7 and Table 2-1.

Figure 2-7. Modified RCRA Subtitle C Barrier, Cross-Sectional Elevation View.

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Figure 2-8. ILAW Container.

Table 2-1. Conformance Assessment of Modified RCRA Subtitle C Barrier to Design Criteria

	Design Criteria	Assessment of Conformance
1.	Minimize moisture infiltration through the cover.	<p>Design facilitates moisture retention in the topsoil layers for removal by evaporation and plant transpiration.</p> <p>Capillary barrier interface at the base of the topsoil will restrict drainage and increase moisture storage capacity in the topsoil layers.</p> <p>A high-saturated hydraulic conductivity value (1 cm/second) is specified for the lateral drainage layer to prevent significant hydraulic head buildup within the layer.</p> <p>The low-permeability (approximately 10^{-8} cm/s) asphalt layer will be highly impervious to water penetration.</p> <p>Numerical performance assessments predict that infiltration through the barrier will be negligible (i.e., less than 0.2% of precipitation).</p>
2.	Design a multilayer cover of materials that are resistant to natural degradation processes.	<p>Long-term durability of asphalt is being evaluated through natural analog studies. Preliminary results indicate that asphalt offers adequate durability over periods in excess of 5,000 years.</p> <p>Except for the asphalt layer, the Modified RCRA Subtitle C Barrier is designed entirely of natural soil and rock that will provide appropriate long-term resistance to chemical and physical weathering.</p>
3.	Design a durable cover that will need minimal maintenance during its design life.	<p>Perennial vegetation will be cultivated on the cover surface to minimize susceptibility to wind and water erosion.</p> <p>The topsoil in Layer 1 will contain 15-wt.% pea gravel. As silt particles are removed from the surface by erosion, pea gravel will form a lag deposit that will tend to protect the surface from further erosion.</p> <p>The surface slope has been limited to 2% to limit wind erosion.</p>
4.	Design a cover with a functional life of 500 years.	<p>The thickness of topsoil in the Modified RCRA Subtitle C Barrier is sufficient to accommodate soil losses at a rate of 2 tons per acre per year for 500 years with no significant adverse effect on performance. (Note: The PA takes no credit for engineered features.)</p>

Table 2-1. Conformance Assessment of Modified RCRA Subtitle C Barrier to Design Criteria

	Design Criteria	Assessment of Conformance
		<p>The Modified RCRA Subtitle C Barrier can accommodate substantial increases in annual precipitation (up to twice ambient) with no significant adverse effect on performance.</p> <p>The 500-year, 24-hour storm has been evaluated. Although the design storm delivers 6.2 cm (2.47 in.) of precipitation, runoff during the 24-hr period is less than 2.5 cm (1 in.) (i.e., runoff is not excessive, and the design storm is unlikely to cause severe erosion of the cover surface).</p> <p>Extremely low soil moisture conditions are expected to be maintained in the coarse-textured soil layer (i.e., Layer 5) below the capillary barrier interface. These conditions are expected to deter root zone development below the topsoil layers.</p> <p>The low-permeability asphalt in Layer 6 is expected to present an impenetrable barrier to plant roots.</p>
5.	Prevent plants from accessing and mobilizing contamination (i.e., prevent root penetration into the waste zone).	
6.	Prevent burrowing animals from accessing and mobilizing contamination.	The low-permeability asphalt in Layer 6 is expected to present an impenetrable barrier to burrowing animals.
7.	Ensure that the top of the waste zone is at least 5 m (16.4 ft) below final grade or include appropriate design provisions for limiting inadvertent human intrusion.	<p>Human habitation of the site surface is considered the most potentially adverse human intrusion scenario for LLW sites.</p> <p>Many radiological waste sites in the 200 Areas have already been stabilized with coarse fill that would approach or exceed these criteria. At other sites, the criteria could be met by placing additional grading fill (same material as in Layer 8).</p> <p>Layer 6 represents a substantial barrier to inadvertent human intrusion. Layer 6 could be excavated, but only with the aid of mechanized equipment.</p>
8.	Facilitate drainage and minimize surface erosion by wind and water.	<p>The surface slope is specified at 2% to provide for coherent drainage off the barrier surface while limiting wind erosion potential.</p> <p>Perennial vegetation will be cultivated on the cover surface to minimize susceptibility to wind and water erosion.</p>

Table 2-1. Conformance Assessment of Modified RCRA Subtitle C Barrier to Design Criteria

	Design Criteria	Assessment of Conformance
		The topsoil in Layer 1 will contain 15-wt.% pea gravel. As silt particles are eroded from the surface, pea gravel will form a lag deposit that will tend to protect the surface from further erosion.
9.	Design the low-permeability layer of the cover to have a permeability less than or equal to any natural subsoils present.	The low-permeability asphalt layer is expected to demonstrate an in-field saturated hydraulic conductivity value on the order of 10^{-8} cm/s. This value is several orders of magnitude lower than the conductivity values of natural subsoils in the 200 Areas.
10.	Design the cover to prevent the migration and accumulation of topsoil material within the lateral drainage layer (i.e., clogging of the lateral drainage layer).	A two-layer graded filter (Layers 3 and 4) separates the topsoil layers from the underlying layers of coarse-textured aggregate materials that will perform the biointrusion prevention and drainage functions. Design specifications for the two graded filter layers conform to standard filter criteria.
11.	For frost protection, the lateral drainage layer and the low-permeability asphalt layer are to be located at least 0.6 m, 15 cm (2 ft, 6 in.) below final grade.	The top of the lateral drainage layer will be situated approximately 1.3 m (4.33 ft.) below final grade.

DOE/RL, 1996, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, DOE/RL-93-33, Rev. 1, August, 1996, prepared by Bechtel Hanford, Inc., for U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Richland Operations Office, Richland, Washington.

2.3 WASTE CHARACTERISTICS

This section provides a detailed description of important characteristics of the ILAW that will be placed in the disposal facility. Formal design proposals for the Phase 1 ILAW are not available at this time. Consequently, the ILAW characteristics information presented in the following sections is based on the currently available information.

2.3.1 Waste Feed Delivery

The DOE will provide the WTP LAW feed streams prepared from processing HLW retrieved from selected RPP underground tanks. Each LAW feed stream will be categorized by its relative composition of chemical and radioactive constituents into one of three defined “waste envelopes,” identified as Envelope A, B, or C. The WTC will process these LAW feeds to get a feed stream suitable for the LAW vitrification process. Selected radionuclides will be removed from the LLW feed by the WTC. The removed radionuclides will be incorporated directly into the IHLW in the WTP.

Both radionuclides and chemicals will be considered in the future PAs (Mann et al. 2000). Although DOE O 435.1 only requires performance assessments for radionuclides, the ORP, along with Ecology, has determined that the technical analyses should support the RCRA permitting requirements as well. Thus, one technical analysis will serve as the basis for protection of the public under the requirements of the Atomic Energy Act and RCRA.

Forty-six radionuclides and 25 chemicals are explicitly treated in the best basis tank inventories. These materials were selected by the TWRS Characterization Program (Kupfer et al. 1999) as being important for safety, disposal, and processing requirements. This set includes all the radionuclides identified as significant in the 1998 ILAW PA (Mann et al. 1998), as well as those identified in the screening studies for the ILAW PAs (Schmittroth and DeLorenzo 1995). For the chemicals identified in the 2001 ILAW PA performance objectives that are not listed in the tank inventories, concentration limits for land disposal (40 CFR 268) were used.

The nominal ILAW inventories for all the materials explicitly included are based on the *Tank Farm Contractor Operation and Utilization Plan* (Kirkbride et al. 2000). The best basis tank-by-tank inventories as of October 1, 1998, were adjusted for waste transfers not accounted for in the BBI and for non-BBI analytes named in the waste treatment contract. The BBI inventories were adjusted to a common date (October 1, 1998). The BBI values are based on a tank-by-tank evaluation of measurements from a tank, as well as modeling results of transfers to and from the tank. The retrieval and feed delivery process was modeled by estimating liquid and solid partitioning (Hendrickson et al. 1999) and following the April 1, 1999, DOE guidance (Taylor 1999b) on schedules and contract requirements. Vitrification losses were explicitly included in the model and are described in Kirkbride et al. (2000).

As noted in the 1998 ILAW PA, the previously accepted half-lives of ^{79}Se and ^{126}Sn are now thought to be underestimates. This underestimate for ^{126}Sn has been confirmed (Appendix E). Thus, inventories for ^{79}Se and ^{126}Sn in Kirkbride et al. (2000) have been multiplied by 0.08 and 0.40, respectively and the corrected figures are shown in Table 2-2.

Table 2-2 provides the total inventory in the tanks and in the ILAW packages, as well as the expected average and maximum concentration in the ILAW packages for each radionuclide and chemical affecting the performance objectives and goals. The upper bound ILAW inventory given in Table 2-2 represents the estimated upper bound for these inventories in ILAW (Mann et al. 2000). The upper bound estimates are either based on contract limits (strontium, technetium, cesium, neptunium, plutonium, americium, and curium) or are taken to be the BBI tank inventories without separation. The average package concentration is calculated by dividing the total inventory for each contaminant by the number of waste packages estimated to be produced (68,471 packages)(Mann et al. 2000). It is noted that the number of waste packages used in Mann et al. (2000) differs from the estimated 80,000 packages of ILAW described in Section 1.2.2.

The following provides short descriptions of key materials:

- ³H No tritium is expected to survive the vitrification process to end up in ILAW packages (Kirkbride et al. 1999).
- ¹⁴C No ¹⁴C is expected to survive the vitrification process and end up in the ILAW packages (Kirkbride et al. 1999).
- ⁷⁹Se Results are based on models, but are considered conservative because the model neglects previous removals such as disposals to cribs.
- ⁹⁰Sr Values are constrained by the current contract (DOE/BNFL 1998) and the assumption that this constraint applies to all ILAW waste.
- ⁹⁹Tc Values based on BBI (reference inventory) and Phase 1 contract requirement (DOE/BNFL 1998) to remove 80 percent of tank inventory from ILAW. Calculation assumes this requirement extends to Phase 2 ILAW production. The tank inventory is felt to be conservative because any losses associated with the offsite shipments are not factored into the BBI inventory for ⁹⁹Tc.
- ¹²⁶Sn Values are based on BBI estimate with separations factor (36 percent of BBI) (Kirkbride et al. 1999). Few tank measurements for ¹²⁶Sn exist. The BBI estimates for ¹²⁶Sn in tanks 241-AZ-101 and 241-AZ-102 are higher than the measurements.
- ¹²⁹I Values are based on BBI and estimate for 0.25 captured and recycled into ILAW (Kirkbride et al. 1999).
- ¹³⁷Cs Values are constrained by the treatment contract (DOE/BNFL 1998). Many of the values are based on total uranium analysis of samples.
- Ra These are daughter products of uranium and thorium that were not treated correctly in the Hanford Defined Waste (HDW) model because uranium, thorium, and plutonium were decayed before separations took place (Kupfer et al. 1999). The values in Table 2-2 have been adjusted based on the Kupfer (1999) estimate for tank inventory.

- ²²⁷Ac These are daughter products of uranium and thorium that were not treated correctly in the HDW model because uranium, thorium, and plutonium were decayed before separations (Kupfer et al. 1999). The values in Table 2-2 have been adjusted based on the Kupfer et al. (1999) estimate for tank inventory.
- ²²⁹Th These are daughter products of uranium and thorium that were not treated correctly in the HDW model because uranium, thorium, and plutonium were decayed before separations (Kupfer et al. 1999). The values in Table 2-2 have been adjusted based on the Kupfer et al. (1999) estimate for tank inventory.
- ²⁴¹Am The values are equal to approximately 10 percent of the total BBI tank inventory estimate (separations estimate from Kirkbride et al. 2000) and are felt to be conservative).
- ²³¹Pa These are daughter products of uranium and thorium that were not treated correctly in the HDW model because uranium, thorium, and plutonium were decayed before separations (Kupfer et al. 1999). The values in Table 2-2 have been adjusted based on the Kupfer et al. (1999) estimate for tank inventory.
- ²³⁷Np The values are based on BBI and large separations factor (44 percent of BBI) from Kirkbride et al. 2000. BBI estimate is felt to be conservative because the inventory estimate is 30 percent higher than the global estimate for the total produced from the reactors. Tanks 241-AN-103 and 241-AN-105 are thought to have the 30 percent of the ²³⁷Np, but only bounding value estimates are provided for these two tanks.
- Pu Values are primarily based on weapons production accountability records and samples. Significant separation factors (5 percent of BBI) are taken from Kirkbride et al. 2000.

Table 2-2. ILAW Package Inventories (Ci for radionuclide and kg for chemical) and Concentrations (Ci/m³ for radionuclide and kg/m³ for chemical) for important constituents.

Material	Tank Inventory	ILAW Inventory	Upper Bound ILAW Inventory	Average Package Concentration	Maximum Batch Concentration
³ H	2.46E+04	0.00E+00	2.46E+04	0.00E+00	0.00E+00
¹⁴ C	4.38E+03	0.00E+00	4.38E+03	0.00E+00	0.00E+00
⁵⁹ Ni	8.58E+02	1.67E+02	8.58E+02	1.06E-03	4.02E-03
⁶⁰ Co	1.99E+04	4.18E+03	1.99E+04	2.64E-02	3.07E-01
⁶³ Ni	8.45E+04	1.62E+04	8.45E+04	1.02E-01	3.91E-01
⁷⁹ Se	5.74E+01	4.80E+01	9.32E+02	3.03E-04	6.84E-02
⁹⁰ Sr ^(a)	5.99E+07	4.50E+06	5.85E+06	2.85E+01	5.43E+01

Table 2-2. ILAW Package Inventories (Ci for radionuclide and kg for chemical) and Concentrations (Ci/m³ for radionuclide and kg/m³ for chemical) for important constituents.

Material	Tank Inventory	ILAW Inventory	Upper Bound ILAW Inventory	Average Package Concentration	Maximum Batch Concentration
⁹³ Zr	4.12E+03	1.25E+03	4.12E+03	7.94E-03	3.37E-02
^{93m} Nb	2.53E+03	8.36E+02	2.53E+03	5.29E-03	4.47E-02
⁹⁹ Tc	2.89E+04	5.79E+03	6.65E+03	3.66E-02	9.96E-02
¹⁰⁶ Ru	1.27E+05	8.94E+02	1.27E+05	5.65E-03	2.59E-01
^{113m} Cd	1.67E+04	7.97E+03	1.67E+04	5.04E-02	2.14E-01
¹²⁵ Sb	2.47E+05	5.20E+04	2.47E+05	3.29E-01	6.50E+00
¹²⁶ Sn	4.64E+02	1.69E+02	1.16E+03	1.07E-03	1.04E-02
¹²⁹ I	1.01E+02	2.20E+01	1.01E+02	1.39E-04	1.81E-03
¹³⁴ Cs	8.71E+04	3.76E+02	4.89E+02	3.73E-01	1.35E+01
¹³⁷ Cs ^(b)	6.37E+07	9.11E+05	1.18E+06	5.76E+00	7.80E+00
¹⁵¹ Sm	2.61E+06	7.80E+05	2.61E+06	4.93E+00	2.42E+01
¹⁵² Eu	1.45E+03	3.07E+02	1.45E+03	1.94E-03	4.21E-02
¹⁵⁴ Eu	1.83E+05	3.77E+04	1.83E+05	2.38E-01	6.13E+00
¹⁵⁵ Eu	1.76E+05	3.15E+04	1.76E+05	1.99E-01	7.36E+00
²²⁶ Ra ^(c)	6.31E-02	5.70E-02	1.14E+03	3.61E-07	1.56E-05
²²⁷ Ac ^(c)	8.76E+01	6.06E-02	8.75E+01	3.83E-07	1.76E-06
²²⁸ Ra ^(c)	7.71E+01	3.30E+01	7.75E+01	2.09E-04	1.06E-03
²²⁹ Th ^(c)	1.81E+00	3.40E-01	1.81E+00	2.15E-06	1.14E-05
²³¹ Pa ^(c)	1.56E+02	3.44E-01	1.53E+02	2.17E-06	1.05E-05
²³² Th	4.40E+00	1.28E+00	4.40E+00	8.09E-06	5.97E-05
²³² U	1.49E+02	3.46E+01	1.49E+02	2.19E-04	1.64E-03
²³³ U	5.72E+02	1.31E+02	5.72E+02	8.26E-04	6.22E-03
²³⁴ U	3.42E+02	4.41E+01	3.42E+02	2.79E-04	1.95E-03
²³⁵ U	1.46E+01	1.79E+00	1.46E+01	1.13E-05	7.97E-05
²³⁶ U	1.24E+01	1.43E+00	1.24E+01	9.03E-06	3.68E-05
²³⁷ Np	1.85E+02	8.10E+01	3.00E+02	5.13E-04	1.78E-03
²³⁸ Pu	2.70E+03	1.06E+02	3.94E+02	6.72E-04	2.69E-03

Table 2-2. ILAW Package Inventories (Ci for radionuclide and kg for chemical) and Concentrations (Ci/m³ for radionuclide and kg/m³ for chemical) for important constituents.

Material	Tank Inventory	ILAW Inventory	Upper Bound ILAW Inventory	Average Package Concentration	Maximum Batch Concentration
²³⁸ U	3.28E+02	4.83E+01	3.28E+02	3.06E-04	2.02E-03
²³⁹ Pu	5.55E+04	3.05E+03	1.13E+04	1.93E-02	9.50E-02
²⁴⁰ Pu	1.13E+04	5.25E+02	1.95E+03	3.32E-03	1.34E-02
²⁴¹ Am	1.07E+05	1.08E+04	4.01E+04	6.85E-02	1.69E+00
²⁴¹ Pu	1.66E+05	7.17E+03	1.66E+05	4.53E-02	1.98E-01
²⁴² Cm	1.72E+02	5.76E+01	1.72E+02	3.64E-04	1.16E-02
²⁴² Pu	1.07E+00	4.49E-02	1.66E-01	2.84E-07	1.69E-06
²⁴³ Am	1.76E+01	6.89E-01	2.55E+00	4.36E-06	9.01E-05
²⁴³ Cm	3.47E+01	6.73E+00	2.49E+01	4.26E-05	5.18E-04
²⁴⁴ Cm	7.84E+02	1.01E+02	3.73E+02	6.36E-04	6.77E-03
Ag+ (silver)	1.51E+03	1.08E+02	3.03E+03	6.83E-04	5.68E-03
As+5 (arsenic)	2.08E+01	1.76E+01	4.15E+01	1.12E-04	7.42E-03
Ba+2 (barium)	1.70E+03	1.86E+01	3.39E+03	1.17E-04	7.24E-03
Be+2 (beryllium)	1.09E+02	6.14E-01	2.18E+02	3.89E-06	5.48E-04
Cd+2 (cadmium)	4.18E+02	6.30E+01	8.36E+02	3.98E-04	5.13E-03
Cl- (chlorine)	9.37E+05	9.31E+05	9.37E+05	5.89E+00	1.55E+01
CN- (cyanide)	1.09E+05	0.00E+00	1.09E+05	0.00E+00	0.00E+00
Cr (total)(chromium)	6.72E+05	2.74E+05	6.72E+05	1.73E+00	1.27E+01
Cu+2 (copper)	3.15E+02	7.33E-01	6.31E+02	4.63E-06	2.54E-05
F- (fluoride)	1.20E+06	9.94E+05	1.20E+06	6.28E+00	2.75E+01
Fe+3 (iron)	1.40E+06	4.48E+04	1.40E+06	2.83E-01	2.86E+00
Hg+2 (mercury)	2.10E+03	1.92E+02	2.10E+03	1.22E-03	3.38E-02
Mn+4 (manganese)	1.96E+05	1.38E+04	1.96E+05	8.71E-02	4.20E-01
NH3 (ammonia)	5.01E+05	0.00E+00	5.01E+05	2.53E+00	4.24E+01
Ni+2 (nickel)	1.80E+05	3.05E+04	1.80E+05	1.93E-01	2.96E+00
NO2- (nitrate)	1.26E+07	0.00E+00	1.26E+07	0.00E+00	0.00E+00
NO3- (nitrite)	5.25E+07	0.00E+00	5.25E+07	0.00E+00	0.00E+00

Table 2-2. ILAW Package Inventories (Ci for radionuclide and kg for chemical) and Concentrations (Ci/m³ for radionuclide and kg/m³ for chemical) for important constituents.

Material	Tank Inventory	ILAW Inventory	Upper Bound ILAW Inventory	Average Package Concentration	Maximum Batch Concentration
Pb+2 (lead)	8.40E+04	7.83E+03	8.40E+04	4.95E-02	2.73E-01
Se+6 (selenium)	6.11E-01	5.33E-01	1.22E+00	3.37E-06	2.96E-05
SO4-2 (sulfate)	3.91E+06	3.39E+06	3.91E+06	2.15E+01	9.12E+01
Tl+3 (thallium)	2.54E+04	NA	5.08E+04	0.00E+00	0.00E+00
Zn+2 (zinc)	2.89E+03	1.98E+03	5.79E+03	1.25E-02	1.19E-01
U (total) (uranium) ^(d)	7.61E+04	1.73E+04	7.61E+04	1.11E-01	2.16E+00
1,1,1-trichlorethane ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00
1,1,2-trichloroethane ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00
Benzene ^(e)	NA	0.00E+00	1.53E+03	0.00E+00	0.00E+00
Carbon tetrachloride ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00
Chloroform ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00
Ethyl benzene ^(e)	NA	0.00E+00	1.53E+03	0.00E+00	0.00E+00
Methylene chloride ^(e)	NA	0.00E+00	4.59E+03	0.00E+00	0.00E+00
N-butyl alcohol ^(e)	NA	0.00E+00	3.98E+02	0.00E+00	0.00E+00
Toluene ^(e)	NA	0.00E+00	1.53E+03	0.00E+00	0.00E+00
Trichloroethylene (1,1,2-Trichloroethylene) ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00
Xylenes-mixed isomers (sum of m-, o-, and p-Xylene) ^(e)	NA	0.00E+00	4.59E+03	0.00E+00	0.00E+00
1,4-dichlorobenzene ^(e)	NA	0.00E+00	9.17E+02	0.00E+00	0.00E+00

(a) The ⁹⁰Sr will have ⁹⁰Y daughter in equilibrium

(b) The ¹³⁷Cs will have ^{137m}Ba daughter in equilibrium.

(c) The values in Table 2-2 have been adjusted based on the Kufper (1999) estimate for tank inventory. Inventories for radionuclides are as of 10/1/98.

(d) Total uranium = total uranium - radioactive inventory.

(e) Tank inventories of specific organic compounds are not available; organic compounds are not expected to survive the vitrification process. "NA" entries refer to components where inventory information is not available.

2.3.2 Packaged Waste Form

The planned waste form is low-activity radioactive glass poured into stainless-steel right circular cylindrical containers that will be managed and disposed of as RCRA mixed waste. An optional approved filler material such as sand or glass may be used to fill any void space inside the package.

A matrix of 55 glass formulations was developed and tested and a data package (McGrail et al. 1999) issued in accordance with the Disposal Authorization Statement (see Appendix A). Testing results of all 55 glasses are reported in detail in PNNL-13101 (Vienna et al. 2000). Tentative conclusions reached in the data package indicate that the glass formulation LAWABP1 is the best performer to date on all of the tests. A large number of experiments with LAWABP1 (and four other glass compositions) are under way.

2.3.2.1 ILAW Specifications. The DOE specified in the Phase 1B contract the required Phase 1 ILAW characteristics, properties, and associated limiting values that would be met by the WTC. The requirements of particular interest for the onsite disposal and closure tasks are as follows (DOE 1998 as amended):

- The waste package is defined as a sealed stainless steel container enclosing a vitrified waste form.
- The package will be fully sealed and its exterior surface cleaned of smearable radioactive contamination.
- Package configuration: The package will be a stainless-steel right circular cylinder. The as-fabricated package dimensions will be constant and have a dimensional tolerance of ± 0.01 m. The external dimensions of the right-cylindrical package, including all appurtenances, will be 1.22 m (diameter) by 2.3 m (height). At the time of acceptance, the ILAW package will stand without support on a flat, horizontal surface and will fit completely and without forcing when lowered vertically into a right circular cylindrical cavity with internal dimensions of 1.27 m (diameter) by 2.4 m (height).
- Package mass will not be greater than 10,000 kg.
- The chemical and radiological composition of the ILAW packages will be documented.
- The radionuclide concentration of the ILAW will be less than Class C limits.
- Average concentration of ^{137}Cs will be less than 3 Ci/m^3 .
- Average concentration of ^{90}Sr will be less than 20 Ci/m^3 .
- Average concentration of ^{99}Tc will be less than 0.1 Ci/m^3 .
- At least 80 percent of ^{99}Tc in feed will be removed.

- The external surface dose rate of the package will not exceed 1,000 mrem/hr.
- The package will have a welded head identification number on the shoulder and side of the package.
- The temperature of the accessible external surfaces of the package will not exceed 50°C.
- The package will contain no detectable free liquids.
- The package contents will not be pyrophoric, ignitable, or reactive.
- The waste form will have a sodium leachability index greater than 6.0.
- The ILAW will be acceptable for land disposal under WAC 173-303 and 40 CFR 268.
- The package will be able to withstand a compression load of 100,000 kg.
- The package will be resistant to degradation and should perform to original specifications for at least 50 years.
- The package will be compatible with crane lifting and movement.

2.3.2.2 ILAW Package Description. The ILAW containers, used to store radioactive glass, are right cylindrical stainless-steel containers, 1.22 m (diameter) by 2.3 m (height) (48 in. by 90 in.) (Figure 2-8). After filling to specified levels with glass, the void space remaining in the container will be filled with inert material. After the filler material is added, the container will contain less than 5 percent void space. The container will be seal-welded to ensure leak-tight containment of the radioactive glass. Each package will have a label welded on the shoulder and side in a readily accessible location. The label will contain unique identification (e.g., serial number) that will be assigned to each package and the corresponding documentation. The number will be readable remotely by an electronic scanner and the label will have a predicted service life of 50 years.

2.3.2.3 ILAW Package Dose Rate. The specification for the ILAW packages stipulates that the external surface dose rate of a package will not exceed 1,000 mrem/hr. However, Kirkbride et al. (1999) shows in Table 3.5-1 that the dose rates are expected to be much less than the maximum. More specifically, the document indicates that the Phase 1 ILAW packages will have a contact dose rate of less than 300 mrem/hr.

After decontamination has been completed and surface smears taken, the surface dose rate is determined to ensure that the package meets contract requirements (The loaded shipping package will not exceed 200 mrem/hr at contact and 10 mrem/hr at 2 m).

3.0 TECHNICAL APPROACH TO CLOSURE

The DOE provides requirements and guidance through its system of orders, manuals, and guides. The primary driver for this closure plan is DOE O 435.1. The objective of this order is to ensure that radioactive waste is managed in a manner that protects workers, public health and safety, and the environment.

This section of the ILAW Closure Plan describes the conceptual technical approach for specific activities that will be conducted to close the facility in a manner that will meet the requirements of DOE O 435.1 and DOE M 435.1-1, DOE Order 5400.5, and applicable EPA and Washington State requirements (Appendix C) and NRC guidance. Design specifications will be developed during CD that is scheduled to begin in FY 2001. This preliminary closure plan presents design criteria and performance specifications developed during the PA (Mann et al. 1998). The PA was conditionally accepted (DOE 1999a) and the waste disposal authorization has been issued (see Appendix A).

3.1 COMPLIANCE WITH PERFORMANCE OBJECTIVES AND OTHER REQUIREMENTS

This section summarizes the results from the ILAW PA under various radiation exposure scenarios and pathways and shows compliance by comparing them to the performance objective values. Because the PA has not taken credit of any reduction in the natural water infiltration rate by the modified Subtitle C RCRA barrier, the PA evaluation is conservative. With the barrier in place, the rate of ILAW contaminant release caused by the leachate will drop and actual dose impacts are expected to be much lower.

3.1.1 All-Pathways Dose

Table 3-1 summarizes the performance objectives from the CA and from the latest ILAW PA analysis along with the estimated impacts from those studies. The CA shows that the disposal of ILAW has no impact for the compliance time studied (1,000 years). According to the latest ILAW PA analysis (Mann et al. 2000), at the DOE compliance time of 1,000 years, the estimated all-pathways dose in mrem/year is over 4,000 times less than the performance objective. Even at 10,000 years, this dose is a factor of approximately 35 lower than the performance objective.

In past Hanford Site PAs and environmental impact statements, the dominant pathway for contaminants was through groundwater. Moisture from precipitation can enter the engineered barrier system and cause contaminants (e.g., in a water-glass interaction) to be released, or might simply carry away already-released contaminants. The contaminated leachate can travel downward through the vadose zone until the contaminants reach the unconfined aquifer where humans can encounter the radioisotopes when recovering the groundwater resource for residential and agricultural uses. From previous analyses (Mann et al. 1998, Mann et al. 2000) supporting the Hanford Low-Level Tank Waste Program, this pathway again is expected to be dominant for contaminant release from ILAW.

The most restrictive performance objective is protecting groundwater from beta/photon radionuclides where the objective is 4.0 mrem/year and the estimate at 10,000 years is 0.17 mrem/year. The point of compliance is a well 100 m downgradient from the facility. The 1998 ILAW PA had higher estimates (e.g., a beta/photon groundwater dose of 2.0 mrem/year) because it used more conservative inputs based on a poorer knowledge base. The 1998 ILAW PA required that the disposal facility be designed so that the infiltration rate is no more than 3 mm/year.

Because the CA found no impact from ILAW, the CA has no impact on ILAW requirements. The ILAW disposal site closure will include construction of a final closure cover for each trench to minimize long-term intrusion or infiltration of water. The final closure cover, a Modified RCRA Subtitle C barrier (See Section 2.2.4), incorporates a drainage pathway to route any infiltrating water away from the waste.

3.1.2 Air Pathway Dose

The air pathway consists of diffusion of radioactive and hazardous gases from the disposal facility to the surface where individuals or groups are potentially at risk of exposure. Gases and vapors will travel upward through the soil to the ground surface. This pathway is maximized with minimum downward water movement. No water flow is considered in the PA calculations for the protection of air resources. The vitrification of LAW removes volatile constituents present in the waste. An insignificant inventory of volatile radionuclides remains in the ILAW.

As the latest analyses, documented in a white paper (Mann et al. 2000), have indicated, the dose from the ILAW placed in the RHW trenches is not expected to be significant (see Table 3-1). As long as 5 meters of material with reasonable porosity lie between the waste and the surface no special design feature is needed to meet the performance objective.

3.1.2.1 Radon Flux. Radon is a naturally occurring radioactive gas produced by the radioactive decay of radium. The concentration of radon and its progeny in air is affected by a number of environmental factors including temperature, humidity, atmospheric pressure, and soil constituency. Temperature inversions commonly produce elevated radon concentrations, as do dry soils. A significant increase in radon emissions is not expected to occur as a result of ILAW disposal. The estimated impact from radon is $<0.001 \text{ pCi m}^{-2} \text{ s}^{-1}$, which is insignificant compared to the performance objective of $20.0 \text{ pCi m}^{-2} \text{ s}^{-1}$ (see Table 3-1).

3.1.3 Inadvertent Intruder

It is possible that an inadvertent intruder could drill a hole through the disposal facility to obtain groundwater. The contaminated cuttings from such an intrusion could then irradiate the intruder through direct radiation, through inhalation, or through ingestion. The latest ILAW PA analysis (Mann et al. 2000) analyzed exposure to such an inadvertent intruder (see Table 3-1). Using present inventory estimates and packing densities, this intruder would be exposed to minor exposure during drilling and more significant exposure while living a residential farming lifestyle. However, both estimates are below performance objectives. At the time of compliance for this scenario (500 years) the combined exposure is a factor of 4 lower than the performance objective with ^{126}Sn contributing over 70 percent of the dose.

The main limits imposed by the 1998 ILAW PA are the amount of ^{126}Sn disposed of in a vertical column, as well as some easily met limits on some other radionuclides.

Table 3-1. Comparison of Estimated Impacts with Performance Objectives from the ILAW PA Analyses and from the CA.

Performance Measure	Performance Objective	Estimated Impact at 1,000 years	Estimated Impact at 10,000 years	
			1998 ILAW PA (a)	Updated Results (b)
All Pathways – CA (c)				
All-pathways [mrem in a year]	100	6	----	----
All Pathways – ILAW PA				
All-pathways [mrem in a year]	25	0.0061	6.4	0.72
Groundwater Pathway – ILAW PA				
Beta/photon emitters in groundwater [mrem in a year]	4.0	0.0017	2.0	0.17
Alpha emitters in groundwater [pCi/L]	15.0	4.2x10 ⁻¹⁴	1.7	0.13
Radium in groundwater [pCi/L]	5.0	0.0	<0.001	0.0
Surface Water Pathway – ILAW PA				
Beta/photon emitters in surface waters [mrem in a year]	1.0	1.4x10 ⁻⁴	0.07	0.014
Alpha emitters in surface waters [pCi/L]	15.0	6.8x10 ⁻¹⁶	0.058	0.011
Radium in surface waters [pCi/L]	0.3	0.0	<0.001	0.0
Air pathway – ILAW PA				
Performance Measure	Performance Objective	Estimated Impact at 1,000 years		
		1998 ILAW PA (a)	Updated Results (b)	
Radon [pCi m ⁻² s ⁻¹]	20.0	<0.001	<0.001	
Other Radionuclides [mrem in a year]	10.0	<10 ⁻⁸	0.00	
Inadvertent Intruder – ILAW PA(a)				
Performance Measure	Performance Objective	Estimated Impact at 500 years		
		1998 ILAW PA (a)	Updated Results (b)	
Acute (drilling) Exposure [mrem]	500.0	5.5	0.9	
Continuous (residential farming) exposure [mrem in a year]	100.0	27.5	27.0	

(a) Mann et al. 1998 (b) Mann et al. 2000 (c) Kincaid et al. 1998

3.1.4 Other Requirements

This section briefly describes the requirements imposed by the PA, RCRA regulations, and DOE Order 5400.5. Compliance with these requirements will be ensured during the development of the CD of the RHW trench.

3.1.4.1 Requirements from Performance Assessment. The ILAW disposal PA imposes certain constraints on the configuration of the closed disposal facility. These constraints are described in Section 6.3 of the PA (Mann et al. 1998), which is included as Appendix D of this document. The constraints are a function of the radionuclide concentrations in the waste and the physical properties of the waste form. The primary constraints are the following:

1. Facility orientation with respect to groundwater flow direction
2. Maximum stacking height of ILAW packages with high concentrations of certain radionuclides
3. Maximum allowable rate of infiltration of water through the closure cover.

3.1.4.2 RCRA-Based Requirements. The proposed ILAW disposal facility will have to be RCRA permitted in accordance with the present EPA classification of the RPP tank wastes (i.e., these wastes are classified as including listed hazardous wastes). The requirements, taken primarily from Title 40 of the CFR, appear in Appendix C.

3.1.4.3 DOE Order 5400.5 Requirements. Institutional control shall continue until the facility can be released (DOE O 435.1) pursuant to DOE Order 5400.5, *Radiation Protection of the Public and the Environment*. Additional DOE Order 5400.5 requirements appear in Appendix C of this document.

3.1.4.4 CERCLA Remedial Action and RCRA Corrective Action. This section is not applicable at this time.

3.1.4.5 Long-Term Site Stewardship. After trench loading and backfilling are completed, the top of the trench will receive a Modified RCRA Subtitle C Barrier cover to provide appropriate protection from the weather and other types of intrusion. ILAW RHW trench disposal facility will be closed as landfills with waste remaining in place. Post-closure activities will be initiated for each trench on completion of closure cap construction for that trench. The length of time required for post-closure care will depend on the results of post-closure monitoring. The need and duration of monitoring will be assessed at each permit review and renewal.

3.2 DETAILED CLOSURE ACTIVITIES

This section describes the various closure activities that will occur in stages. Preliminary trench closure, consisting primarily of backfilling activities, begins soon after placement of the first few packages of ILAW in a trench. These operational/interim closure activities continue until the trench is filled to capacity with ILAW packages. The final closure stage of the RHW trench begins after the last ILAW package is placed and backfilled.

An engineered barrier cover as described in Section 2.2.4 will be installed in accordance with RCRA regulatory requirements to minimize infiltration of precipitation into the trench and hinder the inadvertent intruder from accessing the ILAW packages. Once the trench is closed, operations are reduced to the continuance of monitoring and maintenance of security systems for this facility; the ILAW is safeguarded and monitored by institutional control.

3.2.1 Operational/Interim Closure

The first major step in the operation of the disposal facility will be the receipt of packages of ILAW at the designated RHW Trench. These packages will be delivered by an onsite transport vehicle consisting of a tractor-truck and trailer. A mobile crane system and a shielded transfer bell will be used to remove the ILAW packages from the trailer-mounted shipping container and place them in the trench (Figure 3-1). The crane moves the ILAW package to the face of the advancing array and unloads it adjacent to previously placed packages. The position of the crane hook and package is monitored closely by closed-circuit television to minimize personnel exposure.

To maximize packing density, each cell of ILAW packages is laid out in a close-packed arrangement by staggering the packages to form columns as shown in Figure 3-2. To minimize the radiation exposure of personnel who unload and place the packages, the advancing face of the cell is shielded by a stack of concrete shielding blocks (Figures 3-1 and 3-3). Each block is 0.61 m wide, 0.61 m high, and 2.3 m long with a tongue-in-groove interlock feature to prevent radiation from streaming through interface gaps.

Figure 3-1. Operations Area Package Unloading and Shielding Approach.

Figure 3-2. Close-Packed Arrangement of ILAW Packages.

The shielding blocks must be relocated by the crane periodically as the array advances with the continued placement of ILAW packages. During the movement of concrete shielding blocks, the trench is unavailable for receipt of ILAW packages. The number of blocks to be moved is determined by the width of the cell. If the packages were placed contiguously, the width of the topmost layer in the trench would translate into a potential downtime of several shifts to move the blocks. To facilitate efficient operations and allow the movement of concrete shielding blocks to be completed in one shift, each layer of the trench contains multiple layers.

The RHW trench concept has been described in Section 1.3.1. As shown in Figure 1-4, the bottom layer of ILAW packages in the RHW trench will consist of two cells of six columns each. The middle layer consists of three cells of nine columns each and the top layer has five cells of eight columns each. This layout of ILAW packages in the trench upholds the ALARA principle for radiation exposure during operations as described in the following paragraph. The loading

Figure 3-3. Plan View of RHW Trench Operation.

arrangement will, however, be revisited during advanced conceptual design to optimize trench use.

As an array of ILAW packages advances, the space between the packages is backfilled with previously excavated soil. Soil also is added around the packages that are exposed in the outer column of the arrays. A bulldozer is used to place a backfill layer of soil up to 1 m thick above the top of the ILAW packages. These steps during operations help to minimize the exposed surface area of ILAW packages. A corridor of space is formed between the ILAW package cells in each layer as a result of necessary backfill operations. This space, which will remain unused, is depicted in Figure 1-4. After waste packages have been placed in the trench and covered with soil, temporary covering (i.e., plastic sheeting), tailored to the needs of the situation, will be used to provide protection from the weather. Temporary covering will prevent rain water from creating muddy working conditions in the trench. It also will keep the ILAW containers dry and reduce the amount of precipitation that ends up as leachate.

3.2.1.1 Engineering Drawings. Following detailed design activities, a closure plan update will provide engineering drawings.

3.2.1.2 Specifications for Materials and Placement of Materials. Specifications for materials and their placement will not be available until detailed design has been completed. They will be discussed in an update of this closure plan.

3.2.1.3 Detailed Construction Schedule. A detailed construction schedule will be presented in an update of this closure plan. Figure 1-7 shows a preliminary schedule with the construction start and end dates.

3.2.2 Final Disposal Site Closure

Final disposal site closure consists of installing the modified RCRA Subtitle C barrier on the final trench, decontaminating and decommissioning no-longer-needed ancillary facilities, compiling a final inventory of the low-activity waste disposed in the facility, placing permanent facility location markers, preparing the disposal site for post-closure monitoring and maintenance, and submitting the required certifications that the ILAW disposal facility has been closed to the regulatory authority. A description of the modified RCRA Subtitle C barrier, which is an important part of final site closure, is located in Section 2.2.4 and is illustrated in Figure 2-7.

3.2.2.1 Closure Cover Installation. Individual covers will be used for the ILAW RHW trenches. The reason for these individual covers is that separate excavations are planned for construction of each trench that requires that they be separated some distance to allow for clearance of the 1½-to-1 excavation slopes. A continuous cover over these trenches would consume excessive quantities of material.

The ILAW packages will be backfilled during the interim closure as described in Section 3.2.1. The first step will be to augment the backfill layer with a grading fill layer that will be of variable thickness because of a 2-percent slope requirement for the closure cover. The closure cover installation process is described in detail in Section 2.2.4.

3.2.2.2 Engineering Drawings. Following detailed design activities, a closure plan update will provide engineering drawings.

3.2.2.3 Specifications for Materials and Placement of Materials. Final specifications for materials and placement of materials will not be available until detailed design has been completed. They will be updated in this closure plan as further details become available.

3.2.2.4 Specifications and Plans for Decontamination and Decommissioning of Ancillary Facilities. Specifications and plans for decontamination and decommissioning of ancillary facilities will not be available until detailed design has been completed. They will be furnished in an update of this closure plan.

3.2.2.5 Procedures for Decontamination of Equipment for Release. Procedures for decontamination of equipment for release will be developed during or after detailed design and will be included in a future release of this closure plan. Equipment decontamination will comply with DOE/RL-96-109, the *Hanford Site Radiological Control Manual*.

3.2.2.6 Specifications for Final Release of Disposal Facility Location. Specifications for final release of the disposal facility location will not be available until detailed design has been completed. They will be furnished in an update of this closure plan.

3.2.2.7 Specifications for Emplacement of Permanent Facility Location Markers. Specifications for placement of permanent facility location markers will not be available until detailed design has been completed. They will be furnished in an update of this closure plan.

3.2.2.8 Construction Quality Control Plan. The construction quality control plan will be developed during detailed design and will be presented in an update of this closure plan.

3.2.2.9 Records Management Plan for Documents and Records Generated During Final Closure. Records concerning the disposal-product receipt acceptance and the total inventory of waste placed in the facility will be maintained as a part of the permanent closure documentation (DOE O 435.1 and WAC 246-247), in accordance with HNF-IP-0842, Volume I, *Administration*, Section 2.2, "Records Management." Additional requirements are found in RPP Procedures: RPP-PRO-163, *Documentation and Record Keeping*; RPP-PRO-210, *Records Management Program Standards*; and RPP-PRO-222, *Quality Assurance Records Standards*.

Before final closure of the disposal facility, records of the final inventory of the LLW placed in the facility will be made available for additional updating of the PA and the closure plan.

3.2.2.9.1 Inventory. Before final closure of the disposal facility, records of the final inventory of the LLW placed in the facility will be made available for additional updating of the PA (DOE O 435.1). The total volume of wastes currently stored in the 177 underground storage tanks is estimated at 204,000 m³ in the form of liquids, sludges, and saltcakes. The low-activity fraction of these waste forms will result in approximately 80,000 ILAW packages that, incidentally, also equal 204,000 m³. This figure includes void space, and filler material, as well as the ILAW itself.

3.2.2.9.2 Records. Records concerning the disposal-product receipt acceptance and the total inventory of waste placed in the facility will be maintained as a part of closure (DOE O 435.1 and WAC 246-247).

3.2.2.10 Detailed Construction Schedule for Final Closure Activities. The detailed construction schedule for final closure activities will appear in an update of this closure plan.

3.2.3 Institutional Control

Institutional control shall continue until the facility can be released (DOE O 435.1) pursuant to DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

3.2.3.1 Procedures for Inspection and Maintenance of the Closed Facility. Procedures for inspection and maintenance of the closed facility will not be available until detailed design has been completed. These procedures will be furnished in an update of this closure plan.

3.2.3.2 Procedures for Inspection and Maintenance of the Monitoring System. Procedures for inspection and maintenance of the monitoring system will not be available until detailed design has been completed. These procedures will be furnished in an update of this closure plan.

3.2.3.3 Detailed Schedule for Institutional Control Activities. The detailed schedule for institutional control activities will be developed during or following detailed design and will be presented in a revision of this document.

3.2.3.4 Corrective Action Plan. This section is not applicable at this time.

3.2.3.5 Records Management Plan for Documents and Records Generated During Institutional Control. Records generated during institutional control of the ILAW disposal facility will be maintained as a part of the permanent closure documentation (DOE O 435.1 and WAC 246-247), in accordance with HNF-IP-0842, Volume I, *Administration*, Section 2.2, "Records Management." Additional requirements are found in RPP Procedures: RPP-PRO-163, *Documentation and Record Keeping*; RPP-PRO-210, *Records Management Program Standards*; and RPP-PRO-222, *Quality Assurance Records Standards*.

3.2.4 Unrestricted Release of Site

For the site to be released, it must meet all pertinent requirements of DOE/RL-96-109, *The Hanford Site Radiological Control Manual*; 10 CFR 835, *Occupational Radiation Protection*; and WAC 173-303, *Dangerous Waste Regulations*. Figure 3-4 shows the estimated timetable for the various stages of facility stabilization and control.

The DOE, along with the U.S. Department of Interior, local governments, and affected tribal nations, has recently issued a comprehensive land use plan for the Hanford Site for at least the next 50 years (DOE 1999b). The plan indicates that the 200 Areas (or Central Plateau) would be used exclusively for the management of Hanford Site waste.

The long-term use of the Hanford Site has been the subject of some concern. In 1992, the HFSUWG (consisting of local, state, and federal officials, representatives of tribal nations, people from agriculture and labor, as well as members of environmental and special interest groups) was charged to determine potential future uses of the various parts of the Hanford Site. Their summary report (HFSUWG 1992) makes the following statement:

“In general, the Working Group desires that the overall cleanup criteria for the Central Plateau should enable general usage of the land and groundwater for other than waste management activities in the horizon of 100 years from the decommissioning of waste management facilities and closure of disposal areas.”

However, except for the inadvertent intruder scenario, the scenarios described here assume that some controls remain in place to prevent public intrusion into the disposal site (i.e., the barriers and markers that have been left are effective in preventing open use of the land directly above the disposal site).

3.2.4.1 Authorized Limits for Residual Radioactive Material. Limits for residual radioactive material will comply with the current version of DOE/RL-96-109, Rev. 2, *Hanford Site Radiological Control Manual* (HSRCM-1, Rev. 2); 10 CFR 835, “Occupational Radiation Protection.” The closed site will be posted as an Underground Radioactive Material Area. The closed site is not expected to be a contamination area or a radiation area.

3.2.4.2 Identification of Other Requirements Applicable to Release of Property. No other requirements have been identified for this revision; but should other requirements be identified, they will be added to future versions of this closure plan.

3.2.4.3 Comparison of Existing Site Conditions to Requirements for Unrestricted Release. Because the closed site will be posted as an Underground Radioactive Material Area, it is not expected to meet requirements for unrestricted release.

3.3 MONITORING

During disposal operations, each RHW trench is closed by placing an engineered barrier (cover) over the waste. Final closure follows completion of operations to prepare the disposal site for post-closure monitoring and maintenance. Implementation of monitoring activities for the ILAW disposal systems will begin with the operations phase of a given trench and will continue in some form throughout the subsequent phases of a disposal facility's lifetime. To assist the reader in relating to these defined phases of a disposal facility's lifetime, Figure 3-4 offers a perspective on the approximate duration of these phases. These definitions appear in a guidance document on LLW disposal (DOE 1992). The monitoring activities for the disposal facility will be tailored to the information needs during these respective phases.

3.3.1 Operational/Interim Closure

This section describes monitoring activities that will be implemented during operations to monitor the performance of interim closure measures. During the operational/interim closure

Note: Operation activities are estimated to range from 20 to 50 years, but are shown as 20 years.

Figure 3-4. Approximate ILAW Disposal Site Activity Duration.

(DOE 1992)

activities, the volume of leachate collected, along with any radionuclides, will be monitored. Groundwater also will be monitored in accordance with Hartman et al. (1999). Details on construction of groundwater monitoring wells will be presented in a future update of this closure plan.

3.3.1.1 Application of the Data Quality Objectives (DQO) Process. The DQO process will be applied to identify the specific data that should be collected during monitoring. This process will occur during detailed design activities and will be reported in a later version of this closure plan.

3.3.1.2 Summary of the Sampling and Analysis Plan. The Sampling and Analysis Plan will not be available until detailed design has been completed. This plan will be discussed in an update of this closure plan.

3.3.1.3 Summary of Data Management Procedures. Procedures for data management will not be available until detailed design has been completed. These procedures will be discussed in an update of this closure plan.

3.3.1.4 Description of Data Evaluation Procedures. Procedures for data evaluation will not be available until detailed design has been completed. These procedures will be discussed in an update of this closure plan.

3.3.1.5 Summary of Quality Assurance/Quality Control Procedures. Effective quality and environmental safety and health protection programs will be established and maintained to ensure the requisite level of quality, safety, and environmental compliance in all areas of onsite ILAW transportation and disposal facility design, construction, test evaluation, and maintenance of waste-form qualification.

Project W-520 will implement the quality requirements to ensure that systems, structures, and components (design features) needed to ensure and document product quality are provided and available for use by individuals during the operations phase of the facility life-cycle. The DOE can influence the quality of the immobilized waste by confirming, documenting, and enforcing the continued quality of the WTP's product.

The Quality Assurance Program Plan (QAPP) requirements are derived from 10 CFR 830.120, *Quality Assurance for Nuclear Facilities* and DOE O 414.1, *Quality Assurance*. Public safety, onsite worker safety, environmental protection, and maintenance of waste form qualification are overriding considerations for the project. The commitment to safety by the ORP dictates that management and verification activities to ensure safety and environmental considerations be reflected in the design, procurement, construction, and operation of the project. These management controls and verification activities are described in the referenced QAPP. Audits, surveillance activities, and/or assessments will be conducted periodically by the RPP QA organizations to verify that quality requirements are being met.

The QAPP for ILAW will be developed during detailed design. The Project Hanford implementation of the requirements of 10 CFR 830.120, *Quality Assurance for Nuclear Facilities*, and DOE O 414.1, *Quality Assurance*, are contained in RPP-MP-599, *Project Hanford Quality Assurance Program Description*. Information on the QAPP and QA procedures will be included in an update of this closure plan.

3.3.2 Final Closure/Institutional Care

Within 60 days of post-closure care completion, the DOE will submit by registered mail or an equivalent delivery service to the regulatory authority both a self-certification and a certification by an independent registered professional engineer that the ILAW disposal facility has been closed in accordance with the specifications of the approved post-closure plan.

3.3.2.1 Owner/Operator Post-closure Certification. The DOE will self-certify using the following statement or a statement similar to it.

“I, (name), an authorized representative of the U.S. Department of Energy, Office of River Protection, located at 2440 Stevens Center, Richland, Washington, hereby state and certify that the ILAW disposal facility at the 200 East Area, to the best of my knowledge and belief, has been closed in accordance with the attached approved post-closure plan, and that the post-closure period was completed on (date). (Signature and date.)”

3.3.2.2 Professional Engineer Post-closure Certification. The DOE will engage an independent professional engineer to certify that the ILAW disposal facility has been closed in accordance with the approved post-closure plan. The DOE will require the engineer to sign the following statement or a statement similar to it.

“I, (name), a certified professional engineer, hereby certify, to the best of my knowledge and belief, that I have made visual inspection(s) of the ILAW disposal facility at the 200 East Area and that post-closure activities of the aforementioned facility have been performed in accordance with the attached approved post-closure plan. (Signature, date, state professional engineer license number, business address, and phone number.)”

3.3.2.3 Application of the Data Quality Objectives (DQO) Process. The DQO process will be applied to identify the specific data that should be collected during monitoring. This process will occur during detailed design activities and will be reported on in a later version of this closure plan.

3.3.2.4 Summary of the Sampling and Analysis Plan. The Sampling and Analysis Plan will not be available until detailed design has been completed. This plan will be discussed in an update of this closure plan.

3.3.2.5 Summary of Data Management Procedures. Procedures for data management will not be available until detailed design has been completed. These procedures will be discussed in an update of this closure plan.

3.3.2.6 Description of Data Evaluation Procedures. Procedures for data evaluation will not be available until detailed design has been completed. These procedures will be discussed in an update of this closure plan.

3.3.2.7 Summary of Quality Assurance/Quality Control Procedures. Effective quality and environmental safety and health protection programs will be established and maintained to

ensure a requisite level of quality, safety, and environmental compliance in all areas of onsite ILAW transportation and disposal facility design, construction, test evaluation, and maintenance of waste form qualification.

Project W-520 will implement the quality requirements to ensure that systems, structures, and components (design features) needed to ensure and document product quality are provided and available for use by individuals during the operations phase of the facility life cycle.

The QAPP requirements are derived from 10 CFR 830.120, "Quality Assurance for Nuclear Facilities and " DOE O 414.1, *Quality Assurance*. Public safety, onsite worker safety, environmental protection, and maintenance of waste form qualification are overriding considerations for the project. The commitment to safety by the ORP dictates management and verification activities to ensure safety and environmental considerations are reflected in the design, procurement, construction, and operation of the project. These management controls and verification activities are described in the referenced QAPP. Audits, surveillance activities, and/or assessments will be conducted periodically by the RPP QA organizations to verify that quality requirements are being met.

Information on the QAPP and QA procedures will be presented in an update of this closure plan.

3.3.3 Monitoring Parameters Of Closure Cap System

Section 1.6.2 gives information on a preliminary monitoring plan for the ILAW facility that will document the nature and extent of the monitoring needed. This plan will be published by October 2000. In addition to monitoring to ensure that the ILAW disposal site remains physically undisturbed, it is important to monitor the hydraulic characteristics of the RHW trenches, such as water penetration and drainage requirements. The concept of a leachate collection system and groundwater monitoring wells has been discussed in Section 1.3.3. At this early stage of the development of the ILAW, it is difficult to determine exactly the types and frequency of monitoring.

This section provides information on the monitoring parameters for degradation mechanisms pertaining to the closure cap system. Examples of parameters that could be used to monitor the post-closure physical integrity of the various layers of the closure cap system appear in Tables 3-2, through 3-5. These parameters were derived from the DOE (1992) guidance document on closure of LLW disposal facilities. For a detailed listing of inspection activities to consider regarding closure cover barriers, see Table 5-4 in DOE (1992).

Table 3-2. Candidate Monitoring Parameters for the Degradation Mechanisms Relevant to the Sand/Gravel Layer and Drainage Backfill.

Mechanism	Definition	Measurable Parameters
Sedimentation	Mechanical or hydraulic transport of finer grained particles in pore spaces	Bulk density/porosity Infiltration
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover	Change in cover elevation Horizontal continuity and thickness

DOE, 1992, *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW--133, January 1992, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

Table 3-3. Candidate Monitoring Parameters for Degradation Mechanisms Relevant to the Surface Layers of the Closure Cap System.

<ul style="list-style-type: none"> • Meteorologic conditions <ul style="list-style-type: none"> Rainstorm intensity and duration Wind velocity • Drainage characteristics <ul style="list-style-type: none"> Drainage patterns Rill and gully characteristics Hydraulic roughness Surface runoff rates • Soil properties <ul style="list-style-type: none"> Particle size and shape distribution Particle cohesion Soil bulk density Soil structure and aggregation Organic matter content Chemical properties Aggregate strength and stability • Microtopography <ul style="list-style-type: none"> Elevation Slope aspect, length, and shape 	<ul style="list-style-type: none"> • Vegetation canopy <ul style="list-style-type: none"> Canopy type Average canopy height Percent canopy cover • Vegetation root system <ul style="list-style-type: none"> Extent and length Soil stabilization potential Water extraction potential • Vegetation habitat characteristics <ul style="list-style-type: none"> Succession species Seasonal changes Species hardiness • Animal habitat characteristics <ul style="list-style-type: none"> Succession species Burrow extent and depth
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DOE, 1992, *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW--133, January 1992, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

Table 3-4. Candidate Monitoring Parameters for Degradation Mechanisms Relevant to the Low-Permeability Layers.

Mechanism	Definition	Measurable Parameters
Biological intrusion	Animal or plant intrusion into the cover	Animal or insect burrow depth Plant root depth
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover	Horizontal continuity and thickness
Freeze/thaw	Alternate freezing and thawing of low-permeability layers resulting in cracking	Soil temperature/frost depth

DOE, 1992, *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW--133, January 1992, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

Table 3-5. Candidate Monitoring Parameters for Degradation Mechanisms Relevant to the Vegetative Cover Layer of the Closure Cap System.

Mechanism	Definition	Measurable Parameters
Water erosion	Movement of cover material from normally occurring site precipitation	Precipitation characteristics Soil loss or movement Change in cover elevation
Wind erosion	Movement of cover material from normal occurring site winds	Wind characteristics Soil loss or movement Change in cover elevation
Denudation	Vegetation stress leading to plant death without new plant growth	Vegetation characteristics Climatic conditions Brush fires.
Human activities	Cover disturbance by primarily equipment operation and sample collection	Soil loss or movement Miscellaneous disturbance
Biological intrusion	Animal or plant intrusion into the cover	Animal or insect burrow depth Plant root depth
Freeze/thaw	Alternate freezing and thawing of near-surface soil moisture	Soil temperature Soil cracking or heaving Water ponding or excessive mud
Differential settlement	Mechanical settling from changing weight and compaction of host materials, waste, vault, and cover	Change in cover elevation Cover movement

DOE, 1992, *Considerations for Closure of Low-Level Radioactive Waste Engineered Disposal Facilities*, DOE/LLW--133, January 1992, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

3.3.4 Washington State Requirements for Air Monitoring

Because a sealed-source exemption is expected to be granted, no air monitoring is expected to be required.

3.3.5 Security

A Sitewide security program is in place at the Hanford Site that fully complies with DOE O 470.1, *Safeguards and Security Program* and with DOE O 472.1B, *Personnel Security Activities*. This program will encompass the ILAW disposal facility.

Security will be a part of the activities associated with establishing and implementing the disposal of ILAW on the Hanford Site. The ILAW disposal sites are located within the Hanford Facility controlled-access area. Roadways within the controlled area are restricted to authorized personnel and are not accessible by the general public. The ILAW disposal sites are patrolled by the Hanford Patrol. The ILAW disposal sites are bounded by chain link fences with attached warning signs. The Modified RCRA Subtitle C closure cap that will be placed over the disposal trenches will serve as an inadvertent intruder prevention barrier.

Both non-radiological and radiological safety issues will be addressed by the application of certain security measures. Selected combinations of active and passive types of security systems likely will be used during most phases of the disposal facility lifetime. Examples of active security systems include such measures as full-time security personnel at the facility site, visits to the site and facility at intervals by security staff, and active sensor systems. Passive security systems would include such options as fencing, signs, and access controls.

Security at the disposal site, for general safety purposes, would begin well before ILAW was brought into the site for disposal. All of the Phase 1 and Phase 2 ILAW disposal sites are expected to be located within the 200 Area plateau region of the Hanford Site; within or directly adjacent to the 200 East Area boundary. Both road access and land access presently are controlled with respect to public access.

Disposal site-specific security activities are needed as soon as the construction work on these sites begins. Initially, these activities would focus on access control to ensure a safe working environment for construction workers, project staff, and visitors. Both active and passive types of security options would be applicable, and onsite security staff is likely to be part of the active security measures during this period.

Before the disposal site begins receiving ILAW, the security system will need to be enhanced to fulfill the added obligation for the radiological safety and control of the sites and facilities. Both active and passive types of security measures will be employed during ILAW-receiving, facility-closure, site-closure, and post-closure phases. Once closure work has been completed security personnel might no longer be needed as part of any active security component of these security systems.

3.3.5.1 Security Control Devices. A locking hasp is welded to the cap and casing of each groundwater monitoring well used for monitoring the ILAW disposal areas. The wells are protected from tampering or damage by the installation of steel guard posts and a padlock. The overall condition of each well will be inspected and its condition noted in the logbook during each groundwater sampling event. Items inspected include padlocks, well casing, guard posts, and pumps. All metallic components will be inspected for excessive corrosion.

4.0 CLOSURE SCHEDULE

Disposal operations are expected to last for 30 years or more. A series of disposal trenches will be built as needed with only one built initially. Six trenches are expected to be required for disposal of the ILAW packages. Preliminary closure activities will be instituted for each trench as it is filled. When the trench is full, the closure cap for that trench will be installed.

Figure 1-7 is a representation of the preliminary schedule for the ILAW disposal system. The schedule shows the permitting, design, construction, operations, and closure phases for the new RHW trench disposal facility. The schedule will be updated in revisions of this closure plan.

The dates shown in Figure 1-7 may change as a result of renegotiation of the Tri-Party Agreement (Ecology et al. 1996), which sets the cleanup schedule for the Hanford Site, and as a result of contract renegotiation related to the extension of the treatment contract. Figure 3-4 illustrates the duration of closure activities at the disposal site.

5.0 SAFETY CONSIDERATIONS DURING DISPOSAL FACILITY CLOSURE

The closure task must be conducted in a manner that protects the health and safety of both the facility personnel and the general public. The following sections discuss topical aspects of such safety considerations during closure.

5.1 REGULATORY REQUIREMENTS

The U.S. Occupational Safety and Health Administration (OSHA), NRC, Ecology, EPA, and DOE have issued operational safety requirements relevant to the closure tasks associated with disposal facilities.

The OSHA administers the requirements of the *Occupational Safety and Health Act of 1970*, as amended. The closure and post-closure maintenance operations of the ILAW disposal facility will comply with the occupational safety requirements of 29 CFR 1910.120 (29 CFR 1910).

The applicable Ecology and EPA health and safety regulations for mixed waste disposal facilities focus primarily on hazards associated with the handling operations for hazardous waste (WAC 173-303, 40 CFR 270). The operations, closure, and post-closure monitoring stages of the ILAW disposal facility will meet these regulations.

For further information regarding the NRC and EPA safety related guidance and requirements, see DOE (1992). The DOE Order 5820.2A and its replacement, DOE O 435.1 impose general requirements on safety at such facilities. These orders also cross-link with other DOE orders.

5.1.1 Analyses

In planning and implementing the safety program supporting the disposal facility, the potential safety hazards, risks, and consequences will be assessed in a series of analyses. These analyses will address the closure task and its activities.

Several products will be provided based on the safety analyses. One of these is a preliminary safety evaluation report (PSER), which will support the CD effort. This report will be followed by the final safety analysis report. The PSER (Mouette 1997) has been completed for support of Project W-465 (Project W-465 was the modification and upgrade of the original grout vaults and was entitled *Immobilized Low-Activity Waste Interim Storage Facility*. It has been replaced by the revised W-520, *Immobilized Low-Activity Waste Disposal Facility*, the Remote-Handled Waste Trench). Similar in hazard analyses, Project W-520 PSER and CD is currently underway.

Revisions of this closure plan will incorporate more detailed discussion of the interface between safety analysis work and the design and implementation planning for the closure activities.

5.1.2 Planning

Safe and timely closure of the disposal facility will require careful planning and management. In addition to an operations plan, a detailed health and safety plan is critical to the successful stabilization and closure of a disposal site. This plan should be prepared, reviewed, and approved before stabilization and closure operations begin (DOE 1992).

5.2 IMPLEMENTATION

Closure activities related to safety will be covered by a combination of the parts of the safety program created for the operational phase and supplemental planning and training to address activities unique to the closure task, e.g., decontamination/decommissioning of excess buildings and equipment, construction of the closure barrier system.

5.2.1 Training

During closure, the new-employee orientations, radiation protection training, safety meetings, and training in the operations of equipment that began during the operational phase of the facility will continue. Supplemental training tailored to closure operations will address task-specific areas such as equipment rigging or dismantling and decontamination of the support buildings. A more detailed example of a recommended personnel-training matrix is presented in Table 8-1 of DOE 1992.

5.2.2 Inspections and Reviews

Safety inspections and reviews of ongoing activities will be part of the safety program. The closure task will involve a variety of non-routine construction tasks that will present potential challenges to safe operations. Both routine and non-routine tasks will be addressed by the safety program.

5.2.3 Emergency Response

A link with the overall emergency response program for the proposed disposal facility will need to be maintained to handle events outside the bounds of normal operational safety. The appropriate responses to emergency situations will be incorporated into the training matrix, and drills will be conducted as appropriate to familiarize personnel with emergency scenarios and suitable responses.

6.0 REFERENCES

- 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, as amended.
- 10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.
- 29 CFR 1910, "Occupational Safety and Health Standards," *Code of Federal Regulations*, as amended.
- 40 CFR 260, "Hazardous Waste Management System," *Code of Federal Regulations*, as amended.
- 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.
- 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.
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- DOE Order 5400.1, *General Environmental Protection Program*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, U.S. Department of Energy, Washington, D.C.
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APPENDIX A

*Disposal Authorization for the Hanford Site
Low-Level Waste Disposal Facility
October 1999*

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United States Government

Department of Energy

memorandum

DATE: October 20, 1999.

REPLY TO
ATTN OF: EM-35

SUBJECT: Conditional Acceptance of the Immobilized Low-Activity Tank Waste Disposal Facility Performance Assessment and the Hanford Site 200 Plateau Composite Analysis

TO: Richard French, Manager, Office of River Protection
Keith A. Klein, Manager, Richland Operations Office

An independent review of the Immobilized Low-Activity Tank Waste disposal facility performance assessment and the Hanford Site 200 Plateau composite analysis was completed on July 26, 1999, by a review team led by Joel Case, Idaho Operations Office. The Low-Level Waste Disposal Facility Federal Review Group (LFRG) met on August 16-18, 1999, and agreed with the recommendation of the review team to conditionally accept the performance assessment and the composite analysis. You are authorized for interim operations of the 200 East Area burial grounds and the 200 West Area burial grounds and to continue development of the Immobilized Low-Activity Tank Waste disposal facility by complying with the conditions below. The issuance of a disposal authorization statement is expected by the end of November 1999.

The performance assessment for the Immobilized Low-Activity Tank Waste disposal facility is conditionally accepted. The conditions that must be met are:

1. Provide to the LFRG, per the schedule committed to in the supplemental information provided in the Hanford review team report, documentation of the near-term glass activities to provide confidence that the glass performance assumed in the performance assessment can actually be achieved. The activities and schedule are:
 - Issue to the LFRG, by December 31, 1999, a status report, including a data package, on the testing of the LAWABPI glass, the screening tests of approximately 50 glasses by the Office of Science and Technology, and additional testing on a selected subset (approximately 5) of the Office of Science and Technology glasses. The status report shall include the results from the short-term product consistency test and vapor hydration test experiments on all glasses. Data from the LAWABPI glass and the selected subset of the Office of Science and Technology glasses shall also include results of pressurized unsaturated flow test experiments, single pass flow through tests and mid-term pressurized unsaturated flow tests.

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2. The secondary issues identified in the Hanford review team report shall be addressed as the performance assessment is maintained. Provide to the LFRG, per the schedule committed to in the supplemental information provided by Hanford.

The Hanford Site composite analysis is conditionally accepted. The conditions that must be met are:

1. Provide to the LFRG, by September 30, 2001, an addendum to the composite analysis that addresses the following:
 - Bounding sensitivity analyses of the impact on the composite analysis results of the PUREX tunnels, the chemical separations plants and the CERCLA sites in the 200 Area.
 - Commit either to remediate the Gable Mountain Pond to ensure acceptable dose levels by the planned time of public release or to include it within the 200 Area buffer zone and exclusive waste management area. If the latter is selected, the inclusion of Gable Mountain Pond within the 200 Area buffer zone and exclusive waste management area shall be integrated with Hanford's land use planning documentation.
2. The secondary issues identified in the Hanford review team report will be addressed as the composite analysis is maintained. Also, the following secondary issue, identified during the August 16-17, 1999, LFRG meeting shall be addressed as the composite analysis is maintained:
 - Provide justification for the assumption that the basalt aquifers and interbeds do not contain significant contaminants.

The performance assessment for the 200 East Area burial grounds was conditionally approved on June 30, 1997. There remains some open conditions. The conditions that must be met are:

1. Provide to the LFRG, within eight months of the date of issuance of the disposal authorization statement, documentation that a review of the adequacy of the waste characterization relative to the data needs of the 200 East Area burial grounds performance assessment has been completed. The reliability and accuracy of waste characterization data was an item of concern raised during the review of the performance assessment. The review shall be expanded to include the data needs of the 200 West Area Burial Grounds PA.
2. Also, provide to the LFRG, within eight months of the date of issuance of the disposal authorization statement, a statement confirming that the status of the disposal facility has not changed since approval of the performance assessment.

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The performance assessment for the 200 West Area burial grounds was conditionally approved on June 27, 1996. There remains some open conditions. The conditions that must be met are:

1. Provide to the LFRG, within eight months of the date of issuance of the disposal authorization statement, the review of the adequacy of waste characterization relative to the data needs of the 200 East Area and 200 West Area performance assessment.
2. Provide to the LFRG, within eight months of the date of issuance of the disposal authorization statement, a statement confirming that the status of the disposal facility has not changed since approval of the Performance Assessment.

The Environmental Restoration Disposal Facility was developed prior to the requirement to ensure that the substantive requirements of the DOE waste management order are fulfilled and the review and approval of the composite analysis completes the preparation and approval of an Environmental Restoration Disposal Facility composite analysis in the Defense Nuclear Facilities Safety Board Recommendation 94-2 Implementation Plan. Thus, the Richland Operations Office or Office of River Protection is to provide to DOE Environmental Restoration, within eight months of the date of issuance of the disposal authorization statement, a crosswalk demonstrating that the substantive requirements of DOE Order 435.1 have been fulfilled. An acceptable crosswalk will complete the administrative record process and sustain the applicability of the composite analysis standards to the Environmental Restoration Disposal Facility. The disposal authorization statement for the Environmental Restoration Disposal Facility will be considered satisfied by the issuance of the Record of Decision and DOE acceptance of the crosswalk, which will complete the administrative record process.

Closure plans and monitoring plans are to be prepared within one year of the issuance of the disposal authorization statement. Maintenance plans are to be prepared by March 31, 2000. These plans will be written and approved by the Richland Operations Office or Office of River Protection.

If your staff have any questions regarding this memorandum, they should contact Jay Rhoderick at (301) 903-7211 or Bill Murphie at (301) 903-7216.

James J. Fiore
Acting Deputy Assistant Secretary
for Environmental Restoration
Environmental Management

Mark W. Frei
Acting Deputy Assistant Secretary
for Waste Management
Environmental Management

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United States Government

Department of Energy

memorandum

DATE: October 25, 1999

REPLY TO
ATTN OF: EM-35

SUBJECT: Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities

TO: Richard French, Manager, Office of River Protection
Keith A. Klein, Manager, Richland Operations Office

The Low-Level Waste Disposal Facility Federal Review Group (LFRG) has conducted a review of the performance assessment for the Hanford Site Immobilized Low Activity Tank Waste disposal facility and the Hanford Site 200 Area Plateau composite analysis. The review of the Hanford performance assessment and composite analysis was in accordance with the Department of Energy (DOE) Radioactive Waste Management Order requirements and the commitments made by the DOE in response to Defense Board Recommendation 94-2, Conformance with Safety Standards at DOE Low-Level Nuclear Waste and Disposal Sites.

An independent review of the performance assessment and composite analysis was prepared by a review team chartered by the LFRG. The compliance evaluation (attached) was prepared by the LFRG based on the input from the review team reports and the expert opinions of the LFRG membership. The LFRG used the review team report and the compliance evaluation to develop the disposal authorization statement (attached) which contains the LFRG's recommended formal authorization for disposal operations and the conditions with which the Hanford low-level waste disposal facilities must comply.

We have accepted the LFRG recommendation. Therefore, the Richland Operations Office is authorized to continue operations of the DOE Hanford Site 200 East Area burial grounds and the 200 West Area burial grounds for low-level waste disposal subject to the conditions in the disposal authorization statement. The Office of River Protection is authorized to continue development of the Immobilized Low Activity Tank Waste Disposal Facility subject to the conditions in the disposal authorization statement. The Environmental Restoration Disposal Facility is operated under a Comprehensive Environmental Response Compensation and Liability Act record of decision. However, to ensure that the substantive requirements of DOE Order 435.1 are met, the Richland Operations Office shall develop a crosswalk demonstrating that the substantive requirements of Order 435.1 are met.

Failure by the Hanford site to comply with these conditions should be reported by the Richland Operations Office or Office of River Protection to the LFRG co-chairs, and based upon their recommendation to us, could result in the revoking of the authorization and the immediate shutdown of the disposal facilities. Please note the conditions of approval defined in the disposal authorization statement which must be completed by Hanford to continue authorization of the facilities.

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If your staff have any questions regarding this action or the process for working with the LFRG on meeting the conditions, they should contact Jay Rhoderick (301) 903-7211 or Bill Murphie (301) 903-7216, co-chairs of the LFRG.

James J. Fiore
Acting Deputy Assistant Secretary
for Environmental Restoration
Environmental Management

Mark W. Frei
Acting Deputy Assistant Secretary
for Waste Management
Environmental Management

Attachments (2)

**Disposal Authorization Statement
for the
Department of Energy Hanford Site
Low-Level Radioactive Waste Disposal Facilities**

Revision No.: 0

Effective Date: October 25, 1999

Background:

The DOE Radioactive Waste Management Order requires that a disposal authorization statement be obtained prior to construction of a new low-level waste disposal facility. Field Elements with existing low-level waste disposal facilities shall obtain a disposal authorization statement in accordance with the schedule in the Complex-Wide Low-Level Waste Management Program Plan. The disposal authorization statement shall be issued based on a review of the facility's performance assessment and composite analysis or appropriate CERCLA documentation. The disposal authorization statement shall specify the limits and conditions on construction, design, operations, and closure of the low-level waste facility based on these reviews. A disposal authorization statement is a part of the required radioactive waste management basis for a disposal facility. Failure to obtain a disposal authorization statement or Record of Decision shall result in shutdown of an operational disposal facility or disapproval to initiate construction of a new facility.

Disposal Authorization Statement:

In fulfillment of the requirements of DOE Radioactive Waste Management Order, this Disposal Authorization Statement is hereby issued authorizing the Hanford Site to transfer, receive, possess, and dispose of low-level radioactive waste at the 200 East Area burial grounds, the 200 West Area burial grounds, and the Immobilized Low-Activity Tank Waste disposal facility.

The Hanford Site shall conduct its low-level waste disposal program in accordance with the requirements contained in the following documents.

200 East Area burial grounds

Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds, WHC-EP-0645, November, 1995, M.I. Wood, et al.

Letter from M.W. Frei to Charles Hansen, Conditional Acceptance of the Hanford 200 East Area Burial Ground Performance Assessment, 6/30/97.

Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 East Area Active Burial Grounds, HNF-2005, Rev. 0, M.I. Wood, 12/21/98.

200 West Area burial grounds

Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds, WHC-EP-0645, November, 1995, M.I. Wood, et al.

Letter from S.P. Cowan to Charles Hansen, Conditional Acceptance of the Hanford 200 West Area Burial Ground Performance Assessment, 6/30/96.

Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 West Area Active Burial Grounds, HNF-SD-WM-TI-798, Rev. 0, M.I. Wood, 12/20/96.

Immobilized Low-Activity Tank Waste Disposal Facility

Hanford Immobilized Low-Activity Tank Waste Performance Assessment. DOE/RL-97-69, March 1998, F.M. Mann, et al.

Letter from J. Fiore and M. Frei to Manager for Hanford Office of River Protection and Manager for Richland Operations Office dated September 1999, Subject: Conditional Acceptance of the Immobilized Low-Activity Tank Waste Disposal Facility Performance Assessment and Hanford Site 200 Plateau Composite Analysis.

Hanford Site

Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, PNNL-11800, March 1998, C.T. Kincaid, et al.

Letter from J. Fiore and M. Frei to Manager for Hanford Office of River Protection and Manager for Richland Operations Office dated September 1999, Subject: Conditional Acceptance of the Immobilized Low-Activity Tank Waste Disposal Facility Performance Assessment and Hanford Site 200 Plateau Composite Analysis.

This Disposal Authorization Statement is subject to all applicable rules and Orders now or hereafter in effect and to all conditions specified below. Also, this authorization is applicable to any subsequent revisions and additions to the performance assessments and the composite analysis provided such revisions and additions are in accordance with the performance assessment and composite analysis maintenance program. Applicable permits and reports that comprise the Radioactive Waste Management Basis shall be approved and continue to be maintained current according to the applicable DOE Orders and regulations.

Facility Construction and Design

The 200 East Area burial grounds consists of three types of earthen trenches described in the performance assessment: Category 1 trenches, Category 3 trenches, and trenches for Naval reactor components. The design features of each disposal unit constructed in the field shall conform to the conceptual model used in the performance assessment or special analysis. Any changes in disposal

technology, disposal unit, or waste form must be analyzed and authorized according to the performance assessment and composite analysis maintenance program and approved by DOE. The 200 West Area burial grounds consists of two types of earthen trenches described in the performance assessment: Category 1 trenches and Category 3 trenches. The design features of each disposal unit constructed in the field shall conform to the conceptual model used in the performance assessment or special analysis. Any changes in disposal technology, disposal unit, or waste form must be analyzed and authorized according to the performance assessment and composite analysis maintenance program and approved by DOE.

The Immobilized Low-Activity Tank Waste disposal facility consists of concrete vaults containing glass waste forms from the vitrification of low-activity waste from treatment of Hanford tank waste. This combination of disposal unit and waste form has been analyzed in the Hanford Immobilized Low-Activity Tank Waste performance assessment. The design features of each disposal unit constructed in the field shall conform to the design limits derived from the conceptual models used in the performance assessment or special analysis. Any changes in disposal technology, disposal unit or waste form must be analyzed according to the performance assessment and composite analysis maintenance program and approved by DOE.

Radionuclide Limits, Waste Form, and Packaging

Each disposal unit within the 200 East Area burial grounds, the 200 West Area burial grounds, and the Immobilized Low-Activity Tank Waste disposal facility shall have waste acceptance criteria which provide specific radionuclide disposal limits, waste form restrictions, and descriptions of acceptable waste packages. The waste acceptance criteria shall be based on facility performance assessments, special analyses, and composite analyses as well as safety documentation and criticality considerations. Waste acceptance procedures shall be in place that describe requirements for waste characterization, waste certification and record keeping, as well as the process for authorizing deviations from the requirements. All waste received for disposal at these facilities must conform to the waste acceptance procedures. The waste acceptance criteria shall be reviewed and approved through the facility Radioactive Waste Management Basis.

Closure

Closure plans for the 200 East Area burial grounds, the 200 West Area burial grounds, and the Immobilized Low-Activity Tank Waste disposal facility shall be prepared within one year of the issuance of this disposal authorization statement and submitted to the Richland Operations Office and Office of River Protection for review and approval. These closure plans must address any outstanding closure commitments from the review of the 200 East Area Burial Grounds, the 200 West Area Burial Grounds, and the Immobilized Low-Activity Tank Waste Disposal Facility performance assessments and the composite analysis. Any deviations in the closure plan from the closure concept analyzed in the performance assessments must be analyzed and approved per the performance assessment and composite analysis maintenance program.

Monitoring

Monitoring plans for the 200 East Area burial grounds and the 200 West Area burial grounds shall be written, and approved by the Richland Operations Office. The monitoring plan for the Immobilized Low-Activity Tank Waste disposal facility shall be written, and approved by the Office of River Protection. The monitoring plans shall be implemented within one year of the issuance of this disposal authorization statement. These plans shall be updated at least every five years to reflect

changing facility conditions. The plans shall include monitoring frequencies and protocols for all the data collection required to assess the continued performance of the disposal facilities. These plans shall also include a requirement for comparison with the performance assessment results and development of any corrective action necessary.

Performance Assessment and Composite Analysis Maintenance

Maintenance plans shall be written and approved by the Richland Operations Office for the 200 East Area burial grounds, and the 200 West Area burial grounds, and by Office of River Protection for the Immobilized Low-Activity Tank Waste disposal facility performance assessments and the composite analysis by March 31, 1999. Changes in the disposal facility operation (e.g., waste form, disposal unit design, radionuclide quantity) or in site policy (e.g., land use plan) or strategy (e.g., closure plans, remedial actions) and consequent changes in disposal facility controls shall be managed per the performance assessment and composite analysis maintenance program.

Copies of the annual review of the adequacy of the performance assessments and the composite analysis shall be provided to the Low-Level Waste Disposal Facility Federal Review Group (LFRG).

200 East Area Burial Grounds Performance Assessment Conditions

Provide to the LFRG, within eight months of the date of issuance of this disposal authorization statement, a response to the open condition of acceptance of the performance assessment. The Richland Operations Office shall complete and document a review of the adequacy of waste characterization relative to the data needs of the 200 East Area burial grounds performance assessment. The reliability and accuracy of waste characterization data was an item of concern raised during the review of the performance assessment. The review shall be expanded to include the data needs of the 200 West Area Burial Grounds performance assessment.

Also, provide to the LFRG, within eight months of the date of issuance of this disposal authorization statement, a statement confirming that the status of the disposal facility has not changed since approval of the performance assessment.

200 West Area Burial Grounds Performance Assessment Condition

Provide to the LFRG, within eight months of the date of issuance of this disposal authorization statement, the review of the adequacy of waste characterization relative to the data needs of the 200 East Area and 200 West Area performance assessments.

Also, provide to the LFRG, within eight months of the date of issuance of this disposal authorization statement, a statement confirming that the status of the disposal facility has not changed since approval of the performance assessment.

Environmental Restoration Disposal Facility Condition

The operation of the Environmental Restoration Disposal Facility is authorized by an existing CERCLA Record of Decision. Defense Nuclear Facilities Safety Board Recommendation 94-2 Implementation Plan mentioned that a composite analysis for Environmental Restoration Disposal Facility would "be approved by Headquarters." The review by LFRG completes the approval of the composite analysis for Environmental Restoration Disposal Facility. To ensure consistency between the Record of Decision and the DOE Order 435.1 requirements, the Richland Operations Office is

requested to provide to the DOE Office of Environmental Restoration, within eight months of the date of issuance of this disposal authorization statement, a crosswalk demonstrating that the substantive requirements of DOE Order 435.1 have been fulfilled. An acceptable crosswalk will complete the administrative record process and sustain the applicability of the composite analysis standards to the Environmental Restoration Disposal Facility. The disposal authorization statement for the Environmental Restoration Disposal Facility will be considered satisfied by the issuance of the Record of Decision and DOE acceptance of the crosswalk, which will complete the administrative record process.

Immobilized Low-Activity Tank Waste Disposal Facility Performance Assessment Conditions

Provide to the LFRG, per the schedule committed to in the supplemental information provided the Hanford Review Team, documentation of the near-term glass activities to provide confidence that the glass performance assumed in the performance assessment can actually be achieved. The activities and schedule are:

Issue to the LFRG, by December 31, 1999, a status report, including a data package, on the testing of the LAWABPI glass, the screening tests of approximately 50 glasses by Office of Science and Technology, and additional testing on a selected subset (approximately 5) of the Office of Science and Technology glasses. The status report shall include the results from the short-term product consistency test and vapor hydration test experiments on all glasses. Data from the LAWABPI glass and the selected subset of the Office of Science and Technology glasses shall also include results of pressurized unsaturated flow test experiments, single pass flow through tests and mid-term pressurized unsaturated flow tests.

The secondary issues identified in the Hanford review team report shall be addressed as the performance assessment is maintained.

Hanford Site Composite Analysis Conditions

Provide to the LFRG, by September 30, 2001, an addendum to the composite analysis that addresses the following:

Bounding sensitivity analyses of the impact on the composite analysis results of the PUREX tunnels, the chemical separations plants and the CERCLA sites in the 200 Area.

Commit either to remediate the Gable Mountain Pond to ensure acceptable dose levels by the planned time of public release or to include it within the 200 Area buffer zone and exclusive waste management area. If the latter is selected, the inclusion of Gable Mountain Pond within the 200 Area buffer zone and exclusive waste management area shall be integrated with Hanford's land use planning documentation.

The secondary issues identified in the Hanford review team report shall be addressed as the composite analysis is maintained. Also, the following secondary issue, identified during the August 16-17, 1999 LFRG meeting shall be addressed as the composite analysis is maintained:

Provide justification for the assumption that the basalt aquifers and interbeds do not contain significant contaminants.

Violations of Operational Requirements

Performance assessment and composite analysis commitments that are not met will result in the review of the applicability of continued disposal authorization.

James J. Fiore
Acting Deputy Assistant Secretary
for Environmental Restoration
Environmental Management

Mark W. Frei
Acting Deputy Assistant Secretary
for Waste Management
Environmental Management

Date:

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APPENDIX B

**NRC-EPA Guidance
Environmental Protection Agency**

Directive Number 9487.00-8

*Joint NRC-EPA Guidance on a Conceptual Design Approach for
Commercial Mixed Low-Level Radioactive and Hazardous Waste
Disposal Facilities*

August 3, 1987

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United States
Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

DIRECTIVE NUMBER: 9487.00-8

TITLE: Joint NRC-EPA Guidance on a Conceptual Design
Approach for Commercial Mixed Low-Level Radioactive
and Hazardous Waste Disposal Facilities

APPROVAL DATE: August 3, 1987

EFFECTIVE DATE: August 3, 1987

ORIGINATING OFFICE: OSW

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☐ **DRAFT**

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[]	D- In development or circulating
headquarters

REFERENCE (other documents):

OSWER OSWER OSWER
DIRECTIVE DIRECTIVE L

AUG 3 1987

TO THE STATES, COMPACT REGIONS, AND ALL NRC LICENSEES

SUBJECT: JOINT NRC-EPA GUIDANCE ON A CONCEPTUAL DESIGN APPROACH FOR COMMERCIAL MIXED LOW-LEVEL RADIOACTIVE AND HAZARDOUS WASTE DISPOSAL FACILITIES

Under the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) has jurisdiction over the management of solid wastes with the exception of source, byproduct, and special nuclear material, which are regulated by the U.S. Nuclear Regulatory Commission (NRC) under the Atomic Energy Act (AEA). Low-Level Radioactive Wastes (LLW) contain source, byproduct, or special nuclear materials, but they may also contain chemical constituents which are hazardous under EPA regulations promulgated under Subtitle C of RCRA. Such wastes are commonly referred to as Mixed Low-Level Radioactive and Hazardous Waste (Mixed LLW).

Applicable NRC regulations control the byproduct, source, and special nuclear material components of the Mixed LLW (10 CFR Parts 30, 40, 61, and 70); EPA regulations control the hazardous component of the Mixed LLW (40 CFR Parts 260-266, 268 and 270). Thus, all of the individual constituents of Mixed LLW are subject to either NRC or EPA regulations. However, when the components are combined to become Mixed LLW, neither agency has exclusive jurisdiction under current Federal law. This has resulted in dual regulation of Mixed LLW where NRC regulates the radioactive component and EPA regulates the hazardous component of the same waste.

The attached guidance document provides a conceptual design approach for Mixed LLW disposal facilities. It has been developed jointly by the NRC and EPA to assist commercial LLW disposal site operators and State and Regional Compact regulatory agencies in designing disposal facilities that satisfy both EPA and NRC regulations for Mixed LLW facilities. Although EPA is currently in the process of promulgating regulations that further define the technical parameters for the leak detection, leachate collection, and double liner systems, affected parties may proceed to develop designs for disposal units that will accept Mixed LLW in accordance with existing regulatory requirements. Owners and operators should, however, keep abreast of developing EPA regulations in this area. The attached guidance is based on NRC and EPA regulations in effect on August 1, 1987.

The attached guidance presents a conceptual design approach that meets EPA's regulations covering minimum technology requirements for liners and leachate collection systems, and NRC's requirements for minimization of contact of waste with water, while also assuring long-term stability and avoidance of long-term maintenance which are required by both agencies. The concepts proposed in this document are presented as general guidance; specific design details are expected to be complementary to particular site conditions, so that a license application will have to address site characteristics and their relationship to a proposed design as well as the details of any engineered portion of the facility. The application of this guidance will not affect the requirements for waste disposal facilities to comply with all applicable NRC and EPA regulations.

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The attached guidance should permit licensees to develop safe and effective designs for disposal of Mixed LLW that fully meet the regulatory requirements of both agencies. Depending on the particular type of conceptual design selected by a licensee, EPA may permit variances to the requirements for double liners and leachate collection systems.

Sincerely,

Hugh L. Thompson, Jr., Director
Office of Nuclear Material
Safety and Safeguards
U.S. Nuclear Regulatory Commission

Winston Porter
Assistant Administrator
Office of Solid Waste
and Emergency Response
U.S. Environmental
Protection Agency

Enclosure:
As stated

JOINT NRC-EPA GUIDANCE ON A CONCEPTUAL DESIGN APPROACH FOR
COMMERCIAL MIXED LOW-LEVEL RADIOACTIVE AND HAZARDOUS
WASTE DISPOSAL FACILITIES

Introduction

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPA) requires that the three operating low-level radioactive waste (LLW) disposal facilities remain available through 1992. By that time, all states and compact regions are required to assume complete responsibility for LLW disposal. Both existing and new disposal facilities may receive commercial mixed low-level radioactive and hazardous waste (Mixed LLW), which is regulated by the U.S. Nuclear Regulatory Commission (NRC) under the Atomic Energy Act (AEA), and by the U.S. Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA). Mixed LLW is defined as waste that satisfies the definition of LLW in the LLRWPA and contains hazardous waste that either (1) is listed as a hazardous waste in Subpart D of 40 CFR Part 261 or (2) causes the LLW to exhibit any of the hazardous waste characteristics identified in Subpart C of 40 CFR Part 261. To assist in applying this definition, NRC and EPA issued joint guidance entitled "Guidance on the Definition and Identification of Commercial Mixed Low-Level Radioactive Waste and Answers to Anticipated Questions" on January 8, 1987.

This jointly developed NRC-EPA guidance document presents a conceptual design approach that meets the regulatory requirements of both agencies for the safe disposal of Mixed LLW. Other designs, or variation of the proposed design concept may also be acceptable under the requirements of both agencies and will be reviewed on a case-by-case basis as received.

EPA regulations in 40 CFR Part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, identify the design and operating requirements for owners and operators that dispose of hazardous waste in landfills [264.300 to 264.317]. These regulations involve requirements for the installation of two or more liners and a leachate collection and removal system (LCRS) above and between the liners to protect human health and the environment. Exceptions to the double liner and leachate collection system requirements are allowed, if alternative design and operating practices, together with location characteristics, are demonstrated to EPA's Regional Administrator to be equally effective in preventing the migration of any hazardous constituent into the ground water or surface water.

NRC regulations in 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste, indicate that long-term stability of the waste and the disposal site require minimization of access of water to the waste [61.7(b)(2)] and that the disposal site must be designed to minimize, to the extent practicable, the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal [61.51(a)(6)]. The primary objective of the above NRC regulations is to preclude the possibility of the development of a "bath-tub" effect in which the waste could become immersed in liquid

(e.g., from infiltration of surface water runoff) within a disposal unit below grade with a low-permeability bottom surface.

The guidance on a conceptual design approach that is offered in the subsequent paragraphs is intended to present basic design concepts that are acceptable in addressing the regulations of both the NRC and EPA with respect to requirements for liners, leachate collection systems and efforts to minimize the contact of liquid with the waste. It should be recognized that the guidance is being provided at the conceptual level and that the design and details that are complementary to specific site conditions need to be engineered by potential waste facility owners and operators. The application of the guidance in this document will not affect the requirements for licensees of waste disposal facilities to comply with all applicable NRC and EPA regulations.

Conceptual Design

Sketches and a brief discussion of the design considerations for an above grade disposal unit are provided. This design concept has been developed primarily to demonstrate the integration of EPA's regulatory requirements for two or more liners and a leachate collection system above and between liners and the regulations of the NRC that require the contact of water with the waste be minimized. In addition, the design concept fulfills the need under both agencies' regulations to assure long-term stability and minimize active maintenance after site closure.

In this approach, the Mixed LLW would be placed above the original ground surface in a tumulus that would be blended into the disposal site topography. Schematic details of some of the principal design features of an above grade Mixed LLW disposal unit are provided in the sketches accompanying this guidance document. Figure 1 depicts the three dimensional overall view of a conceptual Mixed LLW disposal unit; Figure 2 provides details of the perimeter berm, liners, and leachate collection system; Figure 3 presents a cross-sectional view of the covered portion of the disposal unit; and Figure 4 describes the final cover system.

In the overall view of the Mixed LLW disposal facility, the double liners and leachate collection and removal system are installed before the emplacement of the Mixed LLW; and the cover system is added at closure. The leak detection tank and leachate collection tank are encircled by a berm that controls surface water runoff from precipitation that would fall directly on the waste facility site. The drainage pipes in the upper primary collection system would collect any leachate that could possibly develop above the top flexible membrane liner and below the emplaced waste. Any leachate collected would drain through the pipes to the primary leachate collection tank where the leachate would be tested and treated, if required. Any leachate collected by the lower leachate collection and removal system would drain to the leak detection tank. The development of significant amounts of leachate from the solidified waste after closure is not anticipated. This is because the closure requirements provide that the cover must be designed and constructed 1) to provide long-term minimization of water infiltration into the closed disposal facility, 2) to function with minimum maintenance, 3) to promote drainage and minimize erosion,

and 4) to have a permeability less than or equal to the permeability of any bottom liner system. It is anticipated that the area shown on Figure 3 between the slope of the final cover and the run-on control berm, where the tanks are located, would be regraded and the tanks removed at the end of the post-closure care period (normally 30 years) when leachate development and collection is no longer a problem.

Figure 2 provides the general details required by EPA regulations for the double liner and leachate collection and removal system. The perimeter berm for leachate runoff control would assure that all leachate is collected below the waste and safely contained and transported through the drainage layers and pipes to the tanks located outside the final cover slope. NRC's regulations requiring minimizing contact of the waste with water are fulfilled by requiring the waste to be placed above the level of the highest water table fluctuation and above the drainage layers where leachate would collect. The bottom elevation of the solidified Mixed LLW would be required in all instances to be at elevations above the top of the perimeter berm.

In Figures 3 and 4, the design concepts for the final cover over the solidified waste zone and the perimeter berm are presented. The actual zone for placement of solidified Mixed LLW may consist of different options, depending on the licensee's selection. Options that would be acceptable include use of stable high integrity waste containers (HICs) that have the spaces between containers filled with a cohesionless, low compressible fill material or placement of the waste in an engineered structure, such as a reinforced concrete vault. A cover system over the waste that would be acceptable to the EPA and NRC is shown in Figure 4. The cover system would consist of (1) an outer rock or vegetative layer to minimize erosion and provide for long-term stability, (2) a filter and drainage layer that transmits infiltrating water off of the underlying low permeability layers, (3) an impervious flexible membrane liner overlying a compacted low permeability clay layer, and (4) a filter and drainage layer beneath the compacted clay layer. If the solidified waste zone does not consist of an engineered vault structure with a top roof, an additional compacted clay layer should be placed immediately above the emplaced waste to direct any water infiltration away from the waste zone. Mixed LLW that contains Class C waste as designated by NRC's regulations would need to provide sufficient thickness of cover materials or an engineered intruder barrier to ensure the required protection against inadvertent intrusion.

Variations on the above described design approach may include placement of the Mixed LLW in an engineered reinforced concrete vault, a steel fiber polymer-impregnated concrete vault, or double-lined high integrity containers that are hermetically sealed. If proposed by license applicants, these variations would be reviewed by both the EPA and NRC on a case-by-case basis to evaluate their acceptability and conformance with established Federal regulations.

For questions related to NRC regulations and design requirements, contact:

Dr. Sher Bahadur, Project Manager
Division of Low-Level Waste Management
and Decommissioning
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Facility specific questions, permitting requirements, variances and other related concerns should be addressed to either the EPA Regional office or State agency authorized to administer the mixed waste program as appropriate. For general questions related to EPA regulations and design requirements, contact:

Mr. Kenneth Skahn, Senior Engineer
Waste Management Division
Mail Stop WH-565E
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

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FIGURE 1- MIXED WASTE DISPOSAL FACILITY

* The compacted clay layer is to be a minimum 3 feet in thickness and have a hydraulic conductivity less than 1×10^{-7} cm/sec

FIGURE 2 - DOUBLE LINER AND LEACHATE COLLECTION SYSTEM

FIGURE 3 - CROSS-SECTIONAL VIEW A-A

(VERTICAL SCALE EXAGGERATED)

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FIGURE 4 - WASTE COVER SYSTEM

(VERTICAL SCALE EXAGGERATED)

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APPENDIX C

Regulatory Requirements

C.1 DOE Order 435.1

The primary requirements imposed by DOE Order 435.1 are as follows:

- a. Department of Energy radioactive waste management activities shall be systematically planned, documented, executed, and evaluated.
- b. Radioactive waste shall be managed to:
 - (1) Protect the public from exposure to radiation from radioactive materials. Requirements for public radiation protection are defined in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.
 - (2) Protect the environment. Requirements for environmental protection are in DOE Order 5400.1, *General Environmental Protection Program*, and DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.
 - (3) Protect workers. Requirements for radiation protection of workers are in 10 CFR 835, *Occupational Radiation Protection*; requirements for industrial safety are in DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*.
 - (4) Comply with applicable Federal, state, and local laws and regulations. These activities shall also comply with applicable Executive Orders and other DOE directives.
- c. All radioactive waste shall be managed in accordance with the requirements in DOE M 435.1-1, *Radioactive Waste Management Manual*.
- d. DOE, within its authority, may impose such requirements, in addition to those established in this Order, as it deems appropriate and necessary to protect health or to minimize threats to life, property, or the environment.

C.2 DOE Manual 435.1-1

The Radioactive Waste Management Manual associated with DOE Order 435.1-1 includes complex-wide requirements, field element requirements, and operations-specific requirements. It specifies the elements of the authorization basis that must be approved by DOE-Headquarters for LLW disposal facilities. The required elements of the authorization basis are:

- Performance Assessment
- Composite Analysis
- Disposal Authorization Statement
- Closure Plan
- Waste Acceptance Criteria
- Monitoring Plan

Additional operations-specific requirements specifically addressing the closure of LLW disposal facilities listed below are taken from DOE M 435.1-1, Chapter IV, Section Q, *Closure*:

- (1) **Disposal Facility Closure Plans.** A preliminary closure plan shall be developed and submitted to Headquarters for review with the performance assessment and composite analysis. The closure plan shall be updated following issuance of the disposal authorization statement to incorporate conditions specified in the disposal authorization statement. Closure plans shall:
 - (a) Be updated as required during the operational life of the facility.
 - (b) Include a description of how the disposal facility will be closed to achieve long-term stability and minimize the need for active maintenance

following closure and to ensure compliance with the requirements of DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.

- (c) Include the total expected inventory of wastes to be disposed of at the facility over the operational life of the facility.
- (2) **Disposal Facility Closure.** Closure of a disposal facility shall occur within a five-year period after it is filled to capacity, or after the facility is otherwise determined to be no longer needed.
 - (a) Prior to facility closure, the final inventory of the low-level waste disposed in the facility shall be prepared and incorporated in the performance assessment and composite analysis, which shall be updated to support the closure of the facility.
 - (b) A final closure plan shall be prepared based on the final inventory of waste disposed in the facility, the plan implemented, and the updated performance assessment and composite analysis prepared in support of the facility closure.
 - (c) Institutional control measures shall be integrated into land use and stewardship plans and programs, and shall continue until the facility can be released pursuant to DOE Order 5400.5, *Radiation Protection of the Public and the Environment*.
 - (d) The location and use of the facility shall be filed with the local authorities responsible for land use and zoning.

C.3 DOE Order 5400.5; C02, Chapter II, Section 1.b. To the extent required by the Clean Air Act, the exposure of members of the public to radioactive materials released to the atmosphere as a consequence of routine DOE activities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem (0.1 mSv). Exposures to, and releases of, radon-220, radon-222, and their respective decay products are subject to DOE limits.

(1) Title 40 CFR Part 61. The public dose limits as outlined in paragraph II.1b are established by EPA regulation 40 CFR Part 61, Subpart H, under the authority of the Clean Air Act. These limits apply offsite where the members of the public reside or abide. Subparts Q and T provide radon flux limits for DOE radium disposal facilities (Chapter IV) and DOE inactive uranium mill tailings sites regulated under 40 CFR Part 192.

(2) AIRDOS/RADRISK Codes. To demonstrate compliance analytically with air emissions for the Clean Air Act Standards, doses to the individuals shall be evaluated using the version of AIRDOS/RADRISK known as CAP-88 or, when available and approved, AIRDOS-PC. Other computer codes or models, such as "Comply Code," which are specifically approved in accordance with 40 CFR Part 61, may also be used.

(3) Environmental Measurements. Compliance may also be demonstrated through environmental or effluent measurements using EPA-approved techniques. In this case, the doses estimated are to individuals in areas offsite, where they are assumed to reside at the point of maximum annual air concentration.

C.4 Environmental Protection Agency

The EPA has promulgated regulations for the disposal of hazardous wastes and for the design, operation, and closure of waste disposal landfills. The requirements, taken primarily from Title 40 of the Code of Federal Regulations, are presented below.

The proposed ILAW disposal facility will have to be RCRA permitted, per the present EPA classification of the Hanford TWRS tank wastes (i.e., these wastes are classified as including listed hazardous wastes). This RCRA permitting is expected to be administered by Ecology, per agreement with the EPA. Ecology's RCRA regulations are per WAC 173-303, and include extensive regulatory requirements regarding waste handling and disposal. In regard to closure, one of the requirements of the RCRA Part B permit is that a closure plan (this document) must be prepared and approved by the regulator regarding hazardous waste disposal facilities.

The primary source of RCRA closure requirements is Title 40 of CFR Part 264, Subpart G:

Subpart G—Closure and Post-Closure

- 264.110 Applicability.
- 264.111 Closure performance standard.
- 264.112 Closure plan; amendment of plan.
- 264.113 Closure; time allowed for closure.
- 264.114 Disposal or decontamination of equipment, structures and soils.
- 264.115 Certification of closure.
- 264.116 Survey plat.
- 264.117 Post-closure care and use of property.
- 264.118 Post-closure plan; amendment of plan.
- 264.119 Post-closure notices.
- 264.120 Certification of completion of post-closure care.

Further detail of 40 CFR 264.111, *Closure performance standard*, is warranted:

The owner or operator must close the facility in a manner that:

- (a) Minimizes the need for further maintenance; and
- (b) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and
- (c) Complies with the closure requirements of this subpart, including, but not limited to, the requirements of §§ 264.178, 264.197, 264.228, 264.258, 264.280, 264.310, 264.351, 264.601 through 264.603, and 264.1102. [51 FR 16444, May 2, 1986, as amended at 52 FR 46963, Dec. 10, 1987; 57 FR 37265, Aug. 18, 1992]

Additional requirements specific to landfills are found in Subpart N:

Subpart N—Landfills

- 264.300 Applicability.
- 264.301 Design and operating requirements.
- 264.302 Action leakage rate.
- 264.303 Monitoring and inspection.
- 264.304 Response actions.
- 264.305—264.308 [Reserved]
- 264.309 Surveying and record keeping.
- 264.310 Closure and post-closure care.
- 264.311 [Reserved]
- 264.312 Special requirements for ignitable or reactive waste.
- 264.313 Special requirements for incompatible wastes.
- 264.314 Special requirements for bulk and containerized liquids.

- 264.315 Special requirements for containers.
- 264.316 Disposal of small containers of hazardous waste in overpacked drums (lab packs).
- 264.317 Special requirements for hazardous wastes FO20, FO21, FO22, FO23, FO26, and FO27.

Further detail of 40 CFR 264.310, *Closure and post-closure care*, is warranted:

- (a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:
 - (1) Provide long-term minimization of migration of liquids through the closed landfill;
 - (2) Function with minimum maintenance;
 - (3) Promote drainage and minimize erosion or abrasion of the cover;
 - (4) Accommodate settling and subsidence so that the cover's integrity is maintained; and
 - (5) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.
- (b) After final closure, the owner or operator must comply with all post-closure requirements contained in §§ 264.117 through 264.120, including maintenance and monitoring throughout the post-closure care period (specified in the permit under § 264.117). The owner or operator must:
 - (1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;
 - (2) Continue to operate the leachate collection and removal system until leachate is no longer detected;
 - (3) Maintain and monitor the leak detection system in accordance with §§ 264.301(c)(3)(iv) and (4) and 264.303(c), and comply with all other applicable leak detection system requirements of this part;
 - (4) Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of subpart F of this part;
 - (5) Prevent run-on and run-off from eroding or otherwise damaging the final cover; and
 - (6) Protect and maintain surveyed benchmarks used in complying with § 264.309. [47 FR 32365, July 26, 1982, as amended at 50 FR 28748, July 15, 1985; 57 FR 3491, Jan 29, 1992].

C.5 Nuclear Regulatory Commission

The NRC has published regulations and guidance for the operation and closure of radioactive waste disposal facilities. The regulations are codified in 10 CFR Part 61 (10 CFR 61). Although DOE facilities are not currently subject to NRC regulations, Project W-520 has elected to utilize this guidance as "good engineering practice". Therefore, the ILAW disposal facility will be designed, operated, and closed with full cognizance of the NRC requirements.

TITLE 10 -- ENERGY

CHAPTER I -- Nuclear Regulatory Commission

PART 61 -- Licensing Requirements for Land Disposal of Radioactive Waste

Subpart A -- General Provisions

- 61.1 Purpose and scope.
- 61.2 Definitions.
- 61.3 License required.
- 61.4 Communications.
- 61.5 Interpretations.
- 61.6 Exemptions.
- 61.7 Concepts.
- 61.8 Information collection requirements: OMB approval.
- 61.9 Employee protection.
- 61.9a Completeness and accuracy of information.
- 61.9b Deliberate misconduct.
- Subpart B -- Licenses
- 61.10 Content of application.
- 61.11 General information.
- 61.12 Specific technical information.
- 61.13 Technical analyses.
- 61.14 Institutional information.
- 61.15 Financial information.
- 61.16 Other information.
- 61.20 Filing and distribution of application.
- 61.21 Elimination of repetition.
- 61.22 Updating of application.
- 61.23 Standards for issuance of a license.
- 61.24 Conditions of licenses.
- 61.25 Changes.
- 61.26 Amendment of license.
- 61.27 Application for renewal or closure.
- 61.28 Contents of application for closure.
- 61.29 Post-closure observation and maintenance.
- 61.30 Transfer of license.
- 61.31 Termination of license.
- Subpart C -- Performance Objectives
- 61.40 General requirement.
- 61.41 Protection of the general population from releases of radioactivity.
- 61.42 Protection of individuals from inadvertent intrusion.
- 61.43 Protection of individuals during operations.
- 61.44 Stability of the disposal site after closure.
- Subpart D -- Technical Requirements for Land Disposal Facilities
- 61.50 Disposal site suitability requirements for land disposal.
- 61.51 Disposal site design for land disposal.
- 61.52 Land disposal facility operation and disposal site closure.
- 61.53 Environmental monitoring.
- 61.54 Alternative requirements for design and operations.
- 61.55 Waste classification.
- 61.56 Waste characteristics.
- 61.57 Labeling.

61.58 Alternative requirements for waste classification and characteristics.

61.59 Institutional requirements.

Subpart E -- Financial Assurances

61.61 Applicant qualifications and assurances.

61.62 Funding for disposal site closure and stabilization.

61.63 Financial assurances for institutional controls.

Subpart F -- Participation by State Governments and Indian Tribes

61.70 Scope.

61.71 State and Tribal government consultation.

61.72 Filing of proposals for State and Tribal participation.

61.73 Commission approval of proposals.

Subpart G -- Records, Reports, Tests, and Inspections

61.80 Maintenance of records, reports, and transfers.

61.81 Tests at land disposal facilities.

61.82 Commission inspections of land disposal facilities.

61.83 Violations.

61.84 Criminal penalties.

Further detail of 10 CFR 61.44, *Stability of the disposal site after closure*, is warranted:

The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

Further detail of 10 CFR 61.51, *Disposal site design for land disposal*, is warranted:

- (a) Disposal site design for near-surface disposal.
 - (1) Site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.
 - (2) The disposal site design and operation must be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives of subpart C of this part will be met.
 - (3) The disposal site must be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives of subpart C of this part will be met.
 - (4) Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.
 - (5) Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.
 - (6) The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.
- (b) Disposal site design for other than near-surface disposal (reserved).

Further detail of 10 CFR 61.52, *Land disposal facility operation and disposal site closure*, is warranted:

- (a) Near-surface disposal facility operation and disposal site closure.
 - (1) Wastes designated as Class A pursuant to Sec. 61.55, must be segregated from other wastes by placing in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between Class A wastes and other wastes will not result in the failure to meet the performance objectives in subpart C of this Part. This segregation is not necessary for Class A wastes if they meet the stability requirements in Sec. 61.56(b) of this part.
 - (2) Wastes designated as Class C pursuant to Sec. 61.55, must be disposed of so that the top of the waste is a minimum of 5 meters below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years.
 - (3) All wastes shall be disposed of in accordance with the requirements of paragraphs (a)(4) through (11) of this section.
 - (4) Wastes must be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled.
 - (5) Void spaces between waste packages must be filled with earth or other material to reduce future subsidence within the fill.
 - (6) Waste must be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with all provisions of Secs. 20.1301 and 20.1302 of this chapter at the time the license is transferred pursuant to Sec. 61.30 of this part.
 - (7) The boundaries and locations of each disposal unit (e.g., trenches) must be accurately located and mapped by means of a land survey. Near-surface disposal units must be marked in such a way that the boundaries of each unit can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey (USGS) or National Geodetic Survey (NGS) survey control stations, must be established on the site to facilitate surveys. The USGS or NGS control stations must provide horizontal and vertical controls as checked against USGS or NGS record files.
 - (8) A buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in Sec. 61.53(d) of this part and take mitigative measures if needed.
 - (9) Closure and stabilization measures as set forth in the approved site closure plan must be carried out as each disposal unit (e.g., each trench) is filled and covered.
 - (10) Active waste disposal operations must not have an adverse effect on completed closure and stabilization measures.

- (11) Only wastes containing or contaminated with radioactive materials shall be disposed of at the disposal site.

C.6 Joint NRC-EPA Guidance

In 1982, the NRC and EPA issued joint guidance on design of mixed LLW disposal facilities. Presented in the document is a conceptual design that both meets EPA's minimum technology requirements for liners and leachate collection systems while satisfying NRC's requirement for minimization of waste contact with groundwater. While RCRA disposal site designs focus on reduction of short-term risk, assuming institutional control and maintenance, NRC focuses on long-term risk with designs that are free of institutional control and maintenance. This joint guidance was intended to create a mutually acceptable design. A copy of the guidance is included as Appendix B.

C.7 State of Washington Requirements

Ecology has authority to enforce the EPA regulations discussed previously. The state regulations are found in WAC 173-303. Closure and postclosure care requirements are found in Chapter 173-303-610 and additional requirements specific to landfills are in Chapter 173-303-665. For the ILAW disposal facility, the state requirements are substantially the same as the federal requirements.

- **WAC 173-303-610 Closure and Postclosure.**

(2) **Closure performance standard.** The owner or operator must close the facility in a manner that:

- (a)(i) Minimizes the need for further maintenance;
- (a)(ii) Controls, minimizes, or eliminates to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous constituents, leachate, contaminated run-off, or dangerous waste decomposition products to the ground, surface water, ground water, or the atmosphere; and
- (a)(iii) Returns the land to the appearance and use of surrounding land areas to the degree possible, given the nature of the previous dangerous waste activity. (Refer to 40 CFR 264.111(a),(b)).

- **WAC 173-303-665 Landfills.**

(6) **Closure and Post-Closure Care**

(a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed to:

- (i) Provide long-term minimization of migration of liquids through the closed landfill;
- (ii) Function with minimum maintenance;
- (iii) Promote drainage and minimize erosion or abrasion of the cover;
- (iv) Accommodate settling and subsidence so that the cover's integrity is maintained; and
- (v) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. (Refer to 40 CFR 264.310(a)(1)-(5)).

(b) After final closure, the owner or operator must comply with all postclosure requirements contained in WAC 173-303-610 (7), (8), (9), and (10) including maintenance and monitoring throughout the postclosure care period. The owner or operator must:

- (i) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;
 - (v) Prevent run-on and run-off from eroding or otherwise damaging the final cover; and
 - (vi) Protect and maintain surveyed benchmarks used in complying with section (5) of this section.
- (Refer to 40 CFR 264.310(b)(1, 2, 3, 4, 5, and 6)).

APPENDIX D

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*Hanford Immobilized Low-Activity
Waste Performance Assessment*

Section 6.3

"Requirements Set By Performance Assessment"

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6.3 REQUIREMENTS SET BY PERFORMANCE ASSESSMENT

6.3.1 Introduction

The analysis presented so far was designed to establish an understanding of how the engineered and natural systems behave. Based on this understanding, this section presents the requirements on the waste form and the disposal facilities based on long-term human health and safety and environmental considerations. Section 6.3.2 defines the methods and describes the parameters used to set those requirements. Those parameters that differ from the base analysis case and the base intruder case are emphasized. Sections 6.3.3 and 6.3.4 describe the calculations and the resulting requirements on waste form and the disposal facilities. Section 6.3.5 describes why the requirements set in Sections 6.3.3 and 6.3.4 are likely to be met.

6.3.2 Requirements Case

Data and methods used to establish requirements on the waste form and the disposal facilities come mainly from the data and methods used in the base analysis case (Chapter 3) and the base intruder cases (Section 5.3). New data obtained since the publication of *Data Packages for the Hanford Low-Level Tank Waste Interim Performance Assessment* (Mann 1995a) and from the analyses contained in this document have been used to modify the data and methods. They are explained in the Sections 6.3.2.1 through 6.3.2.5.

Requirements Case
Requirements on the waste form and on the disposal facility are established by a backwards calculation.

6.3.2.1 Methods Used to Establish Requirements. The homesteader inadvertent intruder and groundwater scenarios are used to establish requirements for the waste form and the disposal facilities. Doses from the driller inadvertent intruder, the surface water, and the air release scenarios are insignificant compared to those from the groundwater and homesteader scenarios.

For the protection of the homesteader, the following equation can be used

$$\sum \sum [I_{ij} / V_j] d_i^h k_i^h H_j < D^h \quad (6.1)$$

or

$$\sum \sum [I_{ij} / V_j] H_j / Y_i < 1.0 \quad (6.2)$$

where the first sum is over contaminants i , the second sum is over containers j in a vertical column emplaced within the disposal facility, and where

- I_{ij} = the inventory of contaminant i in container j (Ci)
- V_j = the volume of container j (m^3)
- d_i^h = the dosimetry factor relating response to concentration of contaminant i in the inadvertent homesteader scenario [$(mrem/yr)/(Ci/m^3)$]
- k_i^h = the factor that accounts for the fraction of waste exhumed during drilling, the mixing of the waste in the soil, and transport to point of exposure ($1/m$)

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67 percent. Therefore, to set limits to protect the groundwater resource, the limiting values will be based on $[1/(1 + 0.67)]$ of the performance objectives (that is, an all-pathways dose of 15 mrem in a year, a beta/photon drinking water dose of 2.4 mrem in a year, and an alpha concentration limit of 9 mrem in a year).

The performance objective used to protect the homesteader (100 mrem in a year) will be used.

6.3.2.4 Disposal Facility Parameters Used to Set Groundwater Protection Requirements.

The following four disposal facility components are important in setting groundwater requirements.

- The surface barrier establishes the recharge rate.
- The hydraulic barrier diverts moisture around the waste.
- The filler material between ILAW containers in the vaults to prevents subsidence.
- The effective disposal facility length is important in determining groundwater mixing.

The difference in the calculational results are small between the case using only natural recharge and the case using the surface barrier for a thousand years followed by natural recharge (presented in Section 4.6.3.1). Therefore, the capability of the surface barrier to reduce recharge from the natural rate will not be used in setting the requirements for groundwater protection. The sensitivity case that used the natural recharge rate at all times will be used. This choice will provide designers with greater flexibility in the design of the surface barrier.

The hydraulic diverter has been present in some conceptual designs (for example, Burbank 1997). However, this component may not survive through final design. Therefore, the properties of a hydraulic diverter were not included when establishing the requirements for setting groundwater protection requirements. Thus, the analysis performed for the Unit Cell calculations rather than the base analysis case form the basis for setting the requirements for groundwater protection (see Table 4-14).

The need to avoid subsidence requires that filler material be present and has long been a part of design. All of the cases run in this analysis assumed such filler material.

The effective disposal length (the volume of the disposal facility divided by the height of the waste and the length of the facility parallel to groundwater flow) obviously depends on the vault design and facility layout. For the existing disposal vaults, the facility length can be determined. However, for the new disposal facilities the allowable length will be treated as a specification.

6.3.2.5 Other Data Changes from Base Analysis Case. Only limited data have been collected since the issuance of *Data Packages for the Hanford Low-Level Tank Waste Interim*

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Performance Assessment (Mann 1995a). The only new information that would affect the setting of requirements is that the K_d value for iodine is now thought to be 0.6 ml/g rather than the 3.0 ml/g used in the base analysis case. The new iodine K_d will be used in setting requirements.

6.3.3 Waste Acceptance Criteria

Using the information in Section 6.3.2, waste acceptance criteria based on long-term human health and safety and environmental protection can be established based on protecting an inadvertent intruder and groundwater resources. The other scenarios do not imply any significant restrictions. Waste acceptance criteria for disposing ILAW should include

$$\sum \sum [I_{ij} / V_j] H_j / Y_i < 1 \quad (6.5 \text{ same as } 6.2)$$

and

$$\sum (I_i R_i / L) / X_i < 1.0 \quad (6.6 \text{ same as } 6.4)$$

where the values of Y_i are given in Table 6-7 and the values of X_i are given in Table 6-8. The meaning of the other symbols is given in Section 6.3.2.1. Table 6-7 also presents the NRC Class maximum concentration limits $[I_{ij} / V_j]$, which apply to all waste disposed of, and the Phase 1 contract average concentration limits, which apply only to waste produced during Phase 1.

For inadvertent intruder protection, the dose values calculated from the base intruder case (Table 5-2) were multiplied by the ratio of the EPA value to the DOE value (where the internal dose dominates) or by unity (where the external dose dominates) to determine new estimates of the intruder doses. The values for Y_i were then determined by increasing the value of $(\sum [I_{ij} / V_j] H_j)$ where the values are taken from the base intruder case) by the ratio of the allowed dose rate (100 mrem in a year) to the new estimate. Where daughters are important, the new estimated doses from the daughters were added to the parents before the ratio was taken. This procedure, basically using equation 6.5, was used because it handles the cases of daughters more straight-forwardly than by determining k_i^h , which also has strong time dependencies when calculating intruder doses (i.e., than by using equation 6.1).

Table 6-7. Waste Acceptance Criteria Based on Protecting Inadvertent Intruder.

$\sum \sum [I_{ij} / V_j] H_j / Y_i < 1.0$. All waste disposed of also must meet the NRC Class C limits, which also are treated as a sum of fractions rule. All waste produced during phase 1 must have lower average concentration than shown in the last column.

Isotope	Y_i Max $\sum [I_{ij} / V_j] H_j$ (Ci/m ³)	Max $[I_{ij} / V_j]$ (Ci / m ³)		Avg $[I_{ij} / V_j]$
		$Y_i * \sum H_j^{EDV (I)}$	NRC Class C	Phase 1 Contract
³ H	1.6×10^{18}	2.2×10^{17}	-	-
¹⁴ C	1.9×10^3	2.6×10^2	8.0	-
⁷⁹ Se	9.9×10^3	1.4×10^3	-	-
⁹⁰ Sr	7.2×10^6	1.0×10^6	7000.0	20.0

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Table 6-7. Waste Acceptance Criteria Based on Protecting Inadvertent Intruder.
 $\sum \sum [I_{ij} / V_j] H_j / Y_i < 1.0$. All waste disposed of also must meet the NRC Class C limits,
 which also are treated as a sum of fractions rule. All waste produced during phase I must
 have lower average concentration than shown in the last column.

Isotope	Y_i Max $\sum [I_{ij}/V_j] H_j$ (Ci/m ²)	Max $[I_{ij} / V_j]$ (Ci / m ³)		Avg $[I_{ij} / V_j]$	
		$Y_i * \sum H_j^{EDV(1)}$	NRC Class C	Phase I Contract	
⁹³ Zr	1.7×10^4	2.4×10^3	-	-	
⁹⁹ Tc	1.5×10^3	2.1×10^2	3.0	0.3	
¹²⁶ Sn	1.9×10^{-1}	2.6×10^{-2}	-	-	
¹²⁹ I	9.2×10^1	1.3×10^1	0.08	-	
¹³⁷ Cs	6.9×10^4	9.6×10^3	4600.0	3.0	
¹⁵¹ Sm	2.3×10^7	3.2×10^6	-	-	
²²⁶ Ra	2.6×10^{-1}	3.7×10^{-2}	$2.7 \times 10^{-1(2)}$	-	
²²⁹ Th	1.4×10^0	1.9×10^{-1}	$2.7 \times 10^{-1(2)}$	-	
²³² Th	1.5×10^{-1}	2.1×10^{-2}	$2.7 \times 10^{-1(2)}$	-	
²³¹ Pa	8.9×10^{-1}	1.2×10^{-1}	$2.7 \times 10^{-1(2)}$	-	
²³³ U	2.6×10^1	3.7×10^0	$2.7 \times 10^{-1(2)}$	-	
²³⁴ U	4.4×10^2	6.1×10^1	$2.7 \times 10^{-1(2)}$	-	
²³⁵ U	2.7×10^0	3.7×10^{-1}	$2.7 \times 10^{-1(2)}$	-	
²³⁶ U	5.0×10^2	6.9×10^1	$2.7 \times 10^{-1(2)}$	-	
²³⁸ U	1.6×10^1	2.3×10^0	$2.7 \times 10^{-1(2)}$	-	
²³⁷ Np	1.9×10^0	2.7×10^{-1}	$2.7 \times 10^{-1(2)}$	-	
²³⁹ Pu	1.1×10^2	1.5×10^0	$2.7 \times 10^{-1(2)}$	-	
²⁴⁰ Pu	1.1×10^2	1.6×10^0	$2.7 \times 10^{-1(2)}$	-	
²⁴¹ Am	8.3×10^1	1.1×10^1	$2.7 \times 10^{-1(2)}$	-	
²⁴³ Am	2.9×10^0	4.1×10^{-1}	$2.7 \times 10^{-1(2)}$	-	
²⁴⁵ Cm	6.4×10^0	8.9×10^{-1}	$2.7 \times 10^{-1(2)}$	-	

(1) A stacking height of 7.2 meters (6 packages) is used.

(2) NRC requirements are expressed in curies per gram. A density of 2.7 g/cm³ was used for the waste form.

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Table 6-8. Waste Acceptance Criteria Based on Groundwater Protection.
 $\sum (I_i R_i / L) / X_i < 1$. Other isotopes do not reach groundwater in 10,000 years or are daughters of those shown in which case they were considered in setting limits.

Isotope	Limiting Quantity	X_i Max IR/L (Ci yr ⁻¹ m ⁻¹)	$X_i * L_{EDF}^{(1,2)}$ Max IR for Existing Vaults (Ci/yr)
⁷⁹ Se	βγ Drinking Water Dose	5.6×10^{-5}	3.5×10^{-3}
⁹⁹ Tc	βγ Drinking Water Dose	3.2×10^{-4}	1.9×10^{-2}
¹²⁹ I	βγ Drinking Water Dose	2.7×10^{-6}	1.7×10^{-4}
²³¹ Pa	All Pathways Dose ⁽³⁾	1.1×10^{-4}	6.8×10^{-3}
²³² U	All Pathways ⁽⁴⁾	3.1×10^{-6}	1.9×10^{-4}
²³³ U	All Pathways ^(3,4)	1.7×10^{-6}	1.0×10^{-4}
²³⁴ U	All Pathways ⁽⁴⁾	1.5×10^{-5}	9.5×10^{-4}
²³⁵ U	All Pathways ⁽⁴⁾	1.6×10^{-5}	9.8×10^{-4}
²³⁶ U	All Pathways ⁽⁴⁾	1.6×10^{-5}	1.0×10^{-3}
²³⁸ U	All Pathways ⁽⁴⁾	1.6×10^{-5}	1.0×10^{-3}

- (1) Conversion factor is for drinking water or for all-pathways as appropriate
 (2) Value used for L for existing disposal vaults is 4 times the width (or 61.6 meters), thus ignoring the space in between the vaults
 (3) Daughters were explicitly considered in setting limits. For other isotopes, daughters were not significant.
 (4) Because uranium is not covered under the Federal Drinking Water guidelines, the all-pathways dose is used as limiting quantity. If uranium were to be included in groundwater, resulting limits would be about a factor of 10 lower.

For expected stacking heights (about 7.2 meters), the NRC Class C limits will be more restrictive than those found in this analysis for most isotopes. This is because the glass waste form makes ingesting or inhaling of the radioisotopes difficult even after they are brought to the surface. A few isotopes (mainly actinides) may be more restricted by this analysis than by the NRC restriction:

- ¹³⁷Cs - if the stack of containers is higher than 15 meters (unlikely)
- ²²⁶Ra, if the stack of containers is higher than 1 meter (very likely)
- ²²⁹Th, if the stack of containers is higher than 5 meters (likely)
- ²³²Th, if the stack of containers is higher than 0.6 meter (very likely)
- ²³¹Pa, if the stack of containers is higher than 3 meters (very likely)
- ²³⁵U - if the stack is higher than 9.9 meters (possible)
- ²³⁷Np - if the stack is higher than 7.2 meters (possible)
- ²⁴³Am - if the stack height is greater than 10.9 meters (unlikely).

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Note that the radioisotope of greatest concern for intruder protection (^{126}Sn) is not one of the radioisotopes restricted by the NRC.

For groundwater protection, the most restrictive limit based on beta/photon drinking water dose, alpha concentration, and all-pathways was used. The value of k_i^{sw} (for each contaminant i reaching the groundwater before 10,000 years) was determined by using equation 6.1, the dose calculated for the Unit Cell sensitivity case having 3.0 mm/yr recharge, and the data (dosimetry, geotechnical, waste form) relevant to that case. New values for d_i^{sw} were calculated by multiplying values for internal doses found in Table B-4 by the ratio of the EPA and DOE internal dosimetry values. Finally, values for X_i were obtained from the definition of X_i $\{X_i = [D_i^{sw} / (d_i^{sw} k_i^{sw})]\}$. The impacts of daughter isotopes were included by placing their doses with their long-lived parent. The effective length of the existing disposal vaults was determined by noting that the groundwater flow will be parallel to the long dimension of the vaults and ignoring the distance between the vaults. Thus, the effective length of the existing disposal vaults was conservatively taken to be four times the width of a vault or 61.6 meters, which ignores the backfill sediments separating the vaults).

6.3.4 Disposal Facility Requirements

Most of the requirements imposed by the performance assessment analysis are on the waste form. However, a few are imposed on the disposal facilities. The major facility requirements deal with subsidence, recharge rate, layout, interactions with the waste form, and intruder protection.

The performance assessment assumes that subsidence is small based on the slow degradation of the waste form and the use of filler materials to minimize voids in the disposal facility. This means that the facility must be constructed without significant void space. In addition, after waste is placed inside the facility, the spaces between the waste containers must be filled with a dry material. Note that the waste containers themselves must not have void spaces (see requirement 2.2.2.5 in Appendix A).

Because the waste form releases contaminants so slowly, the time dependence curve for exposure shows more of a plateau structure than a peaked shaped. Therefore, the major effect of the recharge rate is to delay the arrival of contaminants to the groundwater. If the second group of contaminants (i.e., those having $K_d = 0.6 \text{ mg/l}$, such as uranium) arrived before 10,000 years, the all-pathways dose performance objective would be violated and restrictions would have to be placed on the recharge rate. Based on the sensitivity analyses, the recharge rate must be limited to about 3.0 mm/year (i.e., the natural rate) if no hydraulic diverter is included in the design. If a hydraulic diverter is included, a recharge rate of 100 mm/year would not violate performance objectives. Therefore, if no hydraulic diverter is included in the design, the surface barrier must limit the recharge rate to the natural rate of 3 mm/year. Certainly, gravel surface barriers such as those used in the Hanford Site tank farms would not be suitable. Note that the surface barrier must also deter the inadvertent intruder.

The requirement for groundwater protection $[\sum (I_i R_i / L) / X_i < 1]$ is actually on the disposal system. The designers of the disposal structures must ensure that materials are not used

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that would accelerate waste form degradation and that the vault layout is long enough in relationship to groundwater flow (L) so that the above equation holds. Alternatively, the designers can add components (for example, hydraulic diverters, getters) to minimize the requirements on the waste form.

Designers of the engineered system may wish to add components to provide greater defense-in-depth. The major components would be an improved surface barrier to reduce recharge rate, a hydraulic barrier to divert moisture from the waste, concrete pads to trap uranium, and other getter materials to trap important radionuclides such as technetium. The recharge rate is the main driving function for the system. Having a surface barrier that could reduce this rate would lengthen the time the contaminants take to reach the groundwater. Diverting water away from the waste would likely reduce the contaminant release rate from the waste form and also create a greater moisture shadow under the disposal system that also would delay contaminant travel. Concrete is known to highly retard uranium isotopes, thus reducing its impact during the time of compliance. If an inexpensive getter could be found for technetium, such a material could also have important impacts.

6.3.5 Likelihood of Meeting Requirements

Because the base analysis case met the performance objectives and the sensitivity cases showed the robustness of the assumptions and data, this system can reasonably be expected to meet the requirements imposed in Section 6.3.3 and 6.3.4. This section demonstrates that compliance.

6.3.5.1 Changes from Base Analysis Case. To demonstrate such compliance, some of the data of the base analysis case will be altered to reflect the latest information, particularly the data on tank inventories.

The global tank inventories estimates of Schmittroth (1995) were used for both the base analysis case and in the base intruder case (in the form of average concentrations). However, the TWRS Standard Inventory group has recently determined the best global inventories (Kupfer 1997) and the best tank-by-tank inventories (Washenfelter 1997). These new values (see Section 3.2.4) are used to show that compliance is expected. For ^{78}Se and ^{126}Sn , the inventories were reduced by factors of 6.9 and 2.5, respectively, because of the new half-life data (Section 3.4.7.4) not known to the TWRS Standard Inventory group when they were compiled their results. The separation factors used in the base analysis case (see Table 3-1) will continue to be used because better data are not available yet from the ILAW producers.

The base analysis case assumed that the long-term contaminant release rate would be the same as the short-term release rate specified in the contracts with the ILAW producers (DOE-RL 1996). However, the release rate is known to be a function of space and time. Sensitivity cases were performed modeling the contaminant release from the well-studied

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LD6-5412 glass. For this compliance case, this modeling will be used with the peak values taken from Table 4-16.

The base analysis case used the preconceptual ideas from Eiholzer (1995). Since then, the decision to use the existing disposal vaults has been made (Shade 1997). The dimensions and layouts of the Existing Disposal Vaults will be used to determine compliance. Also, an alternatives-generation analysis using new data has been published (Burbank 1997). This new document is the basis of the design effort. Therefore, its vault layout will be used for the new disposal facilities, which implies an effective facility length of 200 meters, ignoring the backfill sediments separating the vault rows. This new document also will be used as the basis to convert tank waste volume into waste form volume (55.3 x 10⁶ gallons of tank waste into 220,000 m³ of ILAW volume).

6.3.5.2 Inadvertent Intruder Compliance Case. Table 6-9 presents the largest radionuclide concentration in a package assuming that each radionuclide is taken from the tank having the largest concentration of that radionuclide. The stack height is taken as 7.2 meters, or 6 containers, each with the maximum radionuclide concentration. Table 6-9 also displays the radionuclide concentration limitations for a 7.2 meter height given in Table 6-7.

For almost all the radionuclides, a stack of containers each with the maximum concentration would be of no concern, because the concentration values are far below the acceptance limits. For most of the remaining radionuclides (⁹⁰Sr, ⁹⁹Tc, ¹³⁷Cs, ²³⁹Pu, ²⁴⁰Pu, and ²⁴¹Am) that are near or over the limiting values implied by equation 6.2, the producers of the ILAW are required to have the waste form meet NRC Class C limits, which are the basis of waste acceptance for these radionuclides.

The only other radionuclide of concern in meeting the acceptance requirements based on inadvertent intruder protection is ¹²⁶Sn. This radionuclide does not have a Class C limit, so its waste acceptance limit is based on this performance assessment. If the ILAW containers having only waste from tanks A-105, A-106, or AX-104 were stacked on top of each other, the intruder dose would exceed the limit of 100 mrem in a year. However, a number of alternatives exist.

- This performance assessment conservatively assumes that all tin would go to the ILAW product; actually, a significant fraction may be diverted to the high-level waste stream during separations and treatment.
- The three tanks of concern have small volumes of waste (19,000 gallons, 125,000 gallons, and 7,000 gallons). During retrieval, the tank contents are likely to be mixed with other tanks that have significantly lower ¹²⁶Sn concentrations.
- The operators of the disposal facility have the option of placing containers with low concentrations of ¹²⁶Sn on top of a container with a high concentration which would make the stack compliant with the disposal requirements.
- Because these tanks are likely to be processed during the second phase of immobilization, the DOE could by contract have the ILAW producers separate

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the ^{126}Sn from the low-activity waste and ensure that the ^{126}Sn inventory is below the acceptance limits.

Table 6-9. Comparison of ILAW Inventory Concentrations to Maximum Concentration Limits.

Nuclide	Tank	Maximum Concentration Limit (Ci/m ³)		Ratio
		From Tank Inventory and Separations Data ⁽¹⁾	From Waste Acceptance Criteria ⁽²⁾	
^3H	⁽³⁾	0.63	2.2×10^7	0.
^{14}C	⁽⁴⁾	0.035	8.0	0.004
^{79}Se	AX-104	0.015	1.4×10^3	0.
^{90}Sr	AX-104	5.7×10^4	7.0×10^3	8.1 ⁽⁶⁾
^{93}Zr	⁽⁴⁾	0.22	2.4×10^3	0.000
^{99}Tc	SY-101	3.3	3.0	1.1 ⁽⁶⁾
^{126}Sn	AX-104	0.17	0.026	2.5
^{129}I	⁽³⁾	0.002	0.08	0.036
^{137}Cs	A-105	2.3×10^3	4.6×10^3	0.50
^{151}Sm	⁽⁴⁾	143.0	3.2×10^6	0.
^{226}Ra	⁽⁴⁾	2.1×10^{-7}	0.27	0.
^{229}Th	⁽⁴⁾	4.5×10^{-5}	0.27	0.
^{232}Th	⁽⁴⁾	1.2×10^{-4}	0.27	0.
^{231}Pa	⁽³⁾	0.11	0.27	0.39
^{233}U	C-112 ⁽⁵⁾	0.022	0.27	0.080
^{234}U	C-112 ⁽⁵⁾	0.016	0.27	0.058
^{235}U	C-112 ⁽⁵⁾	6.6×10^{-4}	0.27	0.002
^{236}U	C-112 ⁽⁵⁾	3.4×10^{-4}	0.27	0.001
^{238}U	C-112 ⁽⁵⁾	0.015	0.27	0.054
^{237}Np	⁽³⁾	6.4×10^{-3}	0.27	0.024
^{239}Pu	C-202	3.6	0.27	13.3 ⁽⁶⁾
^{240}Pu	⁽⁴⁾	0.33	0.27	1.2 ⁽⁶⁾

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Table 6-9. Comparison of ILAW Inventory Concentrations to Maximum Concentration Limits.

Nuclide	Tank	Maximum Concentration Limit (Ci/m ³)		Ratio
		From Tank Inventory and Separations Data ⁽¹⁾	From Waste Acceptance Criteria ⁽²⁾	
²⁴¹ Am	C-104	6.1	0.27	22.6 ⁽⁶⁾
²⁴³ Am	⁽⁴⁾	1.5×10^{-3}	0.27	0.006
²⁴⁵ Cm	⁽⁴⁾	4.7×10^{-6}	0.27	0.

⁽¹⁾ See Section 3.2, particularly Tables 3-3 and 3-4 for tank-by-tank inventories.

⁽²⁾ From RFP (DOE-RL 1996) and NRC Class C limits (10 CFR 61-2)

⁽³⁾ Value taken from best-estimate global inventory (Kupfer 1997) and assuming that the maximum concentration was 10 times greater than the average concentration

⁽⁴⁾ Value taken from base analysis case (Schmittroth 1995) and assuming that the maximum concentration was 10 times greater than the average concentration

⁽⁵⁾ Value calculated using the largest peak concentration to average concentration for elemental uranium and then ratioing the best-estimate global inventory for each isotope.

⁽⁶⁾ Although the calculated radionuclide concentration from the maximum tank is above the acceptance limit, the ILAW producer is required to increase separation efficiency to ensure that each waste package is below the acceptance limit as it is based on NRC Class C limits.

6.3.5.3 Groundwater Protection Compliance Case. Table 6-10 presents the expected disposal facility release rates from the existing disposal vaults and the new disposal facilities compared to the limitations given in Table 6-8. The two facilities are treated separately because of their different layouts. The existing disposal vaults are expected to take about 6 percent of the waste. It is not presently known how the waste will be distributed among the two facilities. A maximum inventory for the existing disposal vaults also can be calculated from the concentration limits from Table 6-7 and the volume of the vaults. However, this inventory is greater than the estimated ILAW inventory for all the radionuclides of Table 6-10, except for ⁹⁹Tc. For ⁹⁹Tc, the amount is limited because of the average 0.3 Ci/m³ requirement of the contract which allows less than 20 percent of the ⁹⁹Tc to be placed in the existing disposal vaults. For the other radionuclides, all waste is placed in each facility.

Even if all ILAW inventory is placed in each set of facilities, for each radionuclide, the $(I_i R_i / L)$ product is less than the requirement. The sum of $(I_i R_i / L)$ for the new disposal facility is 0.34 of the limit. Using the fact that the amount of Tc to be placed in the existing disposal vaults is limited (by concentrations specified in the RFP and by the volume of the vaults), the sum for the existing disposal vaults is 0.54 of the limit.

Thus, given the conservative assumptions the groundwater can be expected to be protected. In particular, the maximum release rate was used, but as seen from Figure 4-20, this

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maximum release rate is calculated not to occur until 10,000 years after disposal (i.e., at the time of compliance). However, it takes many thousands of years for the contaminants to reach groundwater, so the contamination level in the first 10,000 years will be lower.

The information in Table 6-10 also can be used to back out the maximum allowable contaminant release rate from the facility. For the new disposal facility, the maximum allowable release rate is 2.4 ppm/year assuming that all the inventory of ^{99}Tc is placed in that facility. For the existing disposal vaults, the maximum allowable contaminant release rate is 3.8 ppm/year assuming that 5,000 curies of ^{99}Tc are placed in this facility.

6.4 FURTHER WORK

The TWRS Immobilized Waste Program is committed to providing information to the DOE and the public on the long-range human health and safety and the environmental impacts from the disposal of immobilized low-activity waste. The program realizes that this effort is just the beginning. The program realizes that although the analysis presented in this performance assessment is robust, it relies on much data that are not site-, facility-, and waste form-specific.

Future Work

The ILAW performance assessment team is presently collecting information for the next version of this document. Plans for data collection and documentation for the program's life have been issued.

The program will provide further analyses based on new data and methods as they become available so that the decision makers can make the appropriate decisions. To support these assessments, an extensive data collection and interfacing effort is planned (Mann 1997b, DOE-RL 1997). The type and amount of new data will be guided by the uncertainty of current data and by the importance of such data to the results of future analyses. The major components of this data collection effort are as follows:

- Waste form data collection and model development
- Interactions with disposal facility designers
- Geotechnical data collection and model development
- ILAW inventory
- Other data collection (dosimetry, scenario development, performance objective selection).

6.4.1 Future Performance Assessments

As noted in Section 1.4 and presented in Table 1-2, a number of performance assessments will be produced that incorporate the latest data and information and that present the long-range impacts from disposal. These future performance assessments are expected to reaffirm the conclusions reached in this document. The next performance assessment is planned to be submitted in 2001 to support the start-up of the existing disposal vaults and the

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Table 6-10. Comparison of Expected Release Rates to Allowed Release Rates. The waste form is assumed to have release properties of LD6-5412 and all ILAW is placed in each facility.
IR is the inventory for nuclide times the release rate for that nuclide.

Nuclide	Inventory (Ci)	Existing Disposal Vaults ⁽¹⁾			New Disposal Facilities ⁽²⁾		
		IR Limit (Ci/yr)	Expected IR (Ci/yr)	Expected IR IR Limit	IR Limit (Ci/yr)	Expected IR (Ci/yr)	Expected IR IR Limit
⁷⁹ Se	773.	3.5×10^{-3}	6.0×10^{-4}	0.18	1.1×10^{-2}	6.0×10^{-4}	0.053
⁹⁹ Tc	5.01×10^3 ⁽³⁾	1.9×10^{-2}	2.5×10^{-3}	0.12			
	2.67×10^4		1.3×10^{-2}	0.68	6.4×10^{-1}	1.3×10^{-2}	0.21
¹²⁹ I	6.3	1.6×10^{-4}	3.2×10^{-6}	0.019	5.4×10^{-4}	3.2×10^{-6}	0.006
²³¹ Pa	145. ⁽⁴⁾	6.8×10^{-3}	1.1×10^{-4}	0.017	2.2×10^{-2}	1.1×10^{-4}	0.005
²³³ U	28.6	1.0×10^{-4}	1.8×10^{-5}	0.18	3.4×10^{-4}	1.8×10^{-5}	0.054
²³⁴ U	20.8	9.5×10^{-4}	1.3×10^{-5}	0.014	3.0×10^{-3}	1.3×10^{-5}	0.004
²³⁵ U	0.87	9.8×10^{-4}	5.6×10^{-7}	0.000	3.2×10^{-3}	5.6×10^{-7}	0.000
²³⁶ U	0.045 ⁽⁴⁾	1.0×10^{-3}	2.9×10^{-8}	0.000	3.2×10^{-3}	2.9×10^{-8}	0.000
²³⁸ U	19.3	1.0×10^{-3}	1.3×10^{-5}	0.012	3.2×10^{-3}	1.2×10^{-5}	0.004

⁽¹⁾ For the existing disposal vaults, the effective length (L) is taken to be 61.6 meters.

⁽²⁾ For the new disposal facilities, the effective length (L) is taken to be 200. meters.

⁽³⁾ The lower inventory number of ⁹⁹Tc is for the existing disposal vaults and reflects that the average concentration must be less than 0.3 Ci/m³.

⁽⁴⁾ Inventory values taken from the base analysis case. For other nuclides, inventory values taken from TWRS Standard Inventory.

APPENDIX E

Brodzinski, R. L., e-mail to F. M. Mann,

Bottom Line Half-Life of Sn-126

October 19, 1998

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Author: "**Brodzinski; Ronald L**" <ron.brodzinski@pnl.gov> at ~EXCHANGE
Date: 10/19/98 5:18 PM
Priority: Normal
TO: Frederick M Mann at ~HANFORD07B
TO: "Wyse; Eric J" <eric.wyse@pnl.gov> at ~EXCHANGE
TO: "Lepel; Elwood A" <ea.lepel@pnl.gov> at ~EXCHANGE
TO: "Soderquist; Chuck Z" <chuck.soderquist@exchange.pnl.gov> at ~EXCHANGE
Subject: **Bottom Line Half-Life of Sn-126**

----- Message Contents -----

I believe (unless somebody finds an error in my calculations or we find an error in the fundamental parameters used) that the bottom line for the half-life of Sn-126 is:

2.460 +/- 0.046 x 10⁵ yr.

The value is based on a 0.996 photoefficiency yield of the 666-keV gamma line from the equilibrium decay of Sb-126 + Sb-126m. The uncertainty is the one-sigma propagated uncertainty in the number of atoms of Sn-126 in our sample, the equilibrium count rate of the 666-keV line, and the detector efficiency based on the NIST calibration standard.

For your information, we have redetermined the half-life of Sb-126 to be 12.3903 +/- 0.0074 d (1-sigma). The half-life for the Sb-126m remains the current book value of 19.15 +/- 0.08 m.

As I have stated previously, as a bonus we will publish an open literature paper with the above data plus improved branching fractions for all the gamma lines of the antimony daughters, new gamma ray lines, and corrected levels in Te-126. The manuscript will contain full descriptions of all procedures, including the radiochemical separations that produced the high-specific-activity Sn-126 sample and the mass spectrometric procedures that determined its concentration. This work is in progress, and a draft copy will be forwarded to you as soon as it is compiled.

Ron

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