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7. Abstract

This document was developed to help specify a major demonstration test project of subsurface barrier systems supporting the Tank Waste Remediation System (TWRS) Program. The document focusses discussion on requirements applicable to demonstration of three subsurface barrier concepts: (1) Injected Material, (2) Cryogenic, and (3) Desiccant. Detailed requirements are provided for initial qualification of a technology proposal followed by the pre-demonstration and demonstration test requirements and specifications. Each requirement and specification is accompanied by a discussion of the rationale for it. The document also includes information on the Hanford Site tank farms and related data; the related and currently active technology development projects within the Department of Energy's EM-50 Program; and the overall demonstration test strategy.

Procurement activities and other preparations for actual demonstration testing are on hold until a decision is made regarding further development of subsurface barriers. Accordingly, this document is being issued for information only.

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Subsurface Barrier Demonstration Test Strategy and Performance Specification

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EXECUTIVE SUMMARY

This document provides the technical strategy and specifications to be used to procure the services of contractors to demonstrate subsurface barriers. The Tank Waste Remediation System program has determined that the use of subsurface barriers beneath and around single-shell tanks may prevent or limit leakage that may occur during waste retrieval operations. Three subsurface barrier concepts have emerged for consideration: (1) injected or infused material barriers, (2) cryogenic barriers, and (3) desiccant barriers. These barrier types may be installed in two configurations: close-coupled (against the tank structure) and stand-off (with a soil layer between the tank and barrier). The technical strategy for the demonstration includes the testing of all three barrier types, including the two configurations, contingent upon the receipt of cost-effective and responsive proposals.

The demonstration will be conducted on a reduced scale at an uncontaminated soil site. Laboratory testing may be required before conducting the demonstration as a means of supporting the selection of the most promising and cost-effective technologies.

A set of 22 specifications to be met by contractors are provided in this document. Each specification is supported by a definition of the higher order requirement on which the specification was based. The rationale for each specification and a description of how the Tank Waste Remediation System program will verify conformance are also given.

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ACRONYMS

ALARA	As Low As Reasonably Achievable
DOE	U.S. Department Of Energy
NPT	Normal Pipe Thread
PVC	Polyvinyl Chloride
RCRA	Resource Conservation And Recovery Act
RFP	Request For Proposal
SST	Single-Shell Tank
Tri-Party Agreement	Hanford Federal Facility Agreement And Consent Order
TWRS	Tank Waste Remediation System
WAC	Washington Administrative Code

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) has established the Tank Waste Remediation System (TWRS) to manage safely and dispose of high-level, transuranic wastes, and low-level wastes currently stored in underground tanks at the Hanford Site in Eastern Washington. The scope of TWRS includes tank safety and operations, waste characterization, retrieval, pretreatment, high-level waste immobilization, low-level waste immobilization, as well as associated transfer, interim and long-term storage, and disposal of wastes.

The retrieval element of TWRS includes a work scope to develop subsurface barriers to contain leakage that may result from retrieval operations and to support site closure activities. A number of studies and working meetings have taken place in an effort to determine functions and requirements and the best approach to develop a subsurface barrier system(s). As a result of these activities, three subsurface barrier system concepts have emerged for further consideration: (1) injected or infused material, (2) cryogenic, and (3) desiccant. These barrier concepts may be installed in either close-coupled (against the tank structure) or stand-off (with a soil layer between the tank and barrier) configurations. The TWRS program has begun a demonstration project to further evaluate these concepts. The general approach will be to solicit proposals from industry to conduct the demonstrations on the Hanford Site. The focus of the demonstration will be to construct and operate selected subsurface barrier systems "sub-scale" at an uncontaminated location on the Hanford Site.

Several documents have been prepared to support the demonstration of subsurface barriers. The draft *Functions and Requirements for Subsurface Barriers Used in Support of Single-Shell Tank Waste Retrieval* (Lowe 1994a) defines functions, requirements, issues, and uncertainties regarding the application of subsurface barriers in tank farms at the Hanford Site. The draft *Mission Analysis Report for Demonstration of Subsurface Barriers* (Lowe 1994b) defines specific objectives and measures of success for subsurface barrier demonstrations. The draft *Tank Waste Remediation Systems Subsurface Barriers Test Site* (Karwoski 1994) defines conditions and constraints at an uncontaminated site selected for the demonstrations. The draft *Regulatory Assessment and Permitting Strategy for Use of Underground Barriers at the Hanford Site Tank Farms* (Smith 1994) identifies environmental permits, approvals, and regulatory requirements potentially applicable to subsurface barriers. This document also identifies a permitting strategy and checklist for applications to Hanford Site tank farms. Permitting requirements for the subsurface barrier demonstration are addressed in *Tank Waste Remediation Systems Subsurface Barriers Test Site* (Karwoski 1994).

A document that contains an evaluation of the feasibility of retrieving waste, with and without barriers, will also be written. The results of this evaluation will serve as a primary basis for a decision to proceed with or to cancel plans for the demonstration of subsurface barriers at the Hanford Site. If the evaluation shows that the use of subsurface barriers is feasible and appropriate, a request for proposals (RFP) may be issued.

The solicitation of proposals to conduct demonstrations of subsurface barrier technologies requires the following additional supporting plans and/or documents: (1) a strategy for conducting the demonstrations to meet all programmatic, schedule, fiscal, and technical objectives; (2) a detailed set of demonstration requirements and specifications; (3) background and other supporting technical information; (4) a set of criteria to be used for evaluating proposals; and (5) the RFP. This report provides the first three required documents: the demonstration strategy, the demonstration requirements and specifications, and background and other supporting technical information.

2.0 DEMONSTRATION OBJECTIVES

This document provides technical information to support the procurement of contractors for demonstrations of subsurface barrier technologies. This technical information includes requirements and specifications to be met by selected contractors. The requirements and specifications were derived from functions, requirements, issues, uncertainties, and mission objectives developed for subsurface barrier demonstrations and applications at the Hanford Site. The functions to be performed by subsurface barriers in applications to tank farms at the Hanford Site are defined in *Functions and Requirements for Subsurface Barriers Used in Support of Single-Shell Tank Waste Retrieval* (Lowe 1994a). These functions are based on their potential application to support the retrieval of waste from single-shell tanks (SSTs). These functions and requirements together define the functional baseline for subsurface barriers. This baseline is consistent with the functional baselines of higher level programs, such as the TWRS program, and interrelated activities such, as SST waste retrieval.

The functions and requirements for the TWRS program are provided in the *Tank Waste Remediation System Functions and Requirements* (DOE-RL 1993). The functions and requirements for SST waste retrieval are provided in the *Single-Shell Tank Waste Retrieval System Functions and Requirements* (WHC 1993). General requirements allocated to upper-level functions of the TWRS program and SST waste retrieval (e.g., compliance with all applicable DOE Orders) also apply to subsurface barriers.

The set of functions for SST subsurface barriers defined by Lowe (1994a) is based on the mission of barriers. This mission is to provide confinement of tank leaks during waste retrieval to protect the environment and ensure the safety of workers and the public. These subsurface barrier functions are described in Table 2-1. Lowe (1994a) also identified four sets of requirements for these functions: (1) external requirements, (2) internal requirements, (3) commitments and other negotiated requirements, and (4) mission-driven requirements. Summaries of these four sets of requirements are provided in Table 2-2. The functions and requirements summarized in Table 2-1 and 2-2 pertain to subsurface barrier applications in Hanford Site tank farms. They also serve as bases for the requirements and specifications for the subsurface barrier demonstrations as defined in Section 3.0.

Table 2-1. Functional Descriptions for Subsurface Barrier Systems.

FUNCTION NAME	FUNCTIONAL DESCRIPTION
Confine Leaks	Operate and maintain a system to confine contamination from tank leaks and from previous leaks and spills. Restrict migration of contamination. Verify that effective confinement is provided. Clean up contamination as needed to meet acceptance criteria for turnover.
Minimize Spread	Restrict the movement of contamination from the vicinity of a leak site. Clean up contamination in tank leaks and from previous leaks and spills.
Limit Movement	Prevent or restrict the physical movement of leaked waste (e.g., by reduced permeability).
Clean up Soil	Remove contamination in tank farm by soil flushing or other effective technique.
Maintain Confinement	Monitor and actively control barrier operation to ensure effective overall confinement. Generate operating records.
Monitor Integrity	Monitor barrier operation to determine integrity of confinement system. Compare results to standards. Identify needed integrity adjustments. Report integrity data.
Monitor Performance	Monitor barrier operation to determine performance of confinement system. Compare results to standards. Identify needed performance adjustments. Report performance data.
Repair Defects	Adjust confinement system to meet integrity and performance standards.

Table 2-2. Requirements for Subsurface Barriers (Sheet 1 of 2).

I. EXTERNAL REQUIREMENTS

- Prevent further migration of existing spills and leaks.
- Prevent exceedance of radionuclide limits in groundwater.
- Prevent exceedance of limits for radioactive airborne emissions.
- Prevent exceedance of limits for other hazardous or noxious airborne emissions in work environments.
- Meet criteria for the characterization, packaging, storage, treatment, and disposal of any solid waste generated.
- Minimize the quantity of waste produced.
- Incorporate monitoring and leak detection into the design to provide rapid identification of leaks and assess system integrity.
- Implement the as low as reasonably achievable (ALARA) policy regarding radiation protection in system design and planning.
- Evaluate the environmental impacts of materials added to the environment.
- Determine and comply with the requirements of the safety classification.
- Select applicable quality assurance requirements for design, procurement, and construction commensurate with the safety classification.
- Design equipment and systems to meet the natural phenomena loading criteria commensurate with the safety classification.
- Design equipment to withstand the effects of design-basis accidents and to operate under adverse open-field conditions.

II. INTERNAL REQUIREMENTS

- Design barrier to accommodate variations in tank and tank farm design.
- Design barrier to accommodate different waste compositions, leak volumes, and leak rates.

Table 2-2. Requirements for Subsurface Barriers (Sheet 2 of 2).

- Consider equipment and structural interferences at the tank farm in barrier design.
- Design barrier to accommodate variations in subsurface geology.
- Prevent impact on tank farm operations.
- Prevent exceedance of tank dome loading limits.
- Prevent exceedance of tank sidewall and bottom loading limits.
- Prevent exceedance of concrete temperature limits.

III. COMMITMENTS AND OTHER NEGOTIATED REQUIREMENTS

- Design, install, and operate barrier to support the waste retrieval schedule.
- Employ systems that are consistent with obtaining a revision to the Part A Resource Conservation and Recovery Act (RCRA) Permit and/or Closure Plan.
- Employ systems that limit new emissions to facilitate pre-construction review and approval by U.S. Environmental Protection Agency (EPA).
- Employ best available toxics and radionuclide control technology for new emissions to support Washington State Department of Ecology (Ecology) approval.

IV. MISSION-DRIVEN REQUIREMENTS

- Minimize soil contamination and prevent exceedance of contaminant limits in groundwater.
- Design the barrier system to function for 30 years without major repair or replacement.

Lowe (1994a) also identifies a list of issues and uncertainties that must be resolved before subsurface barriers can be implemented in Hanford Site tank farms. Resolution of these issues and uncertainties may result in defining several new requirements. These issues and uncertainties include the following:

- Final definition of retrieval schedules
- Definition of closure requirements regarding level of cleanup and the function of barriers after remediation work is completed
- Assessment of the present tank structural integrity
- Extent of present soil contamination in Hanford Site tank farms
- Definition of cleanup requirements for solid waste
- Definition of the safety classification of subsurface barriers.

The functions, requirements, issues, and uncertainties regarding the application of subsurface barriers in Hanford Site tank farms has been used to define a framework of constraints and objectives for demonstrating subsurface barrier concepts. The draft *Mission Analysis Report for Demonstration of Subsurface Barriers* (Lowe 1994b) identifies six mission objectives for conducting subsurface barrier demonstrations.

1. Determine the benefit and cost-effectiveness of using barriers to confine tank leaks during retrieval.
2. Evaluate the use of barriers in cleanup of previous leaks and the role of barrier in tank farm closure.
3. Identify barrier technologies suitable to the Hanford Site.
4. Assess the capabilities of vendors to supply complete barrier systems.
5. Demonstrate the feasibility of using barriers to confine tank leaks.
6. Install and operate subsurface barriers.

These six demonstration objectives, and the functions, requirements, issues, and uncertainties identified earlier were used to define a technical strategy, specific requirements, and specifications for conducting demonstrations. The technical strategy (Section 3.0) describes a plan for demonstrating subsurface barriers on a reduced scale at an uncontaminated test site. This will allow flexibility for conducting several demonstrations during the same time period under nearly equal conditions. The objective of this approach is to provide a common basis for comparing subsurface barrier technologies. The strategy also defines a step-wise approach for evaluating the technologies. This approach is designed to ensure that resources are and remain focused on the most promising technologies.

The requirements and specifications for the subsurface barrier demonstrations are provided in Section 4.0. These requirements and specifications are organized to facilitate the preparation of the RFP and the evaluation criteria for selecting contractors.

The objective of Appendix A is to provide a summary of data on Hanford Site tank farms as background information for inclusion in the RFP. The objective of Appendix B is to introduce prospective bidders to potentially relevant research and development activities being conducted under DOE's EM-50 division with the intent of promoting transfer of applicable technologies to this demonstration.

3.0 SUBSURFACE BARRIER DEMONSTRATION STRATEGY

This section defines the strategy for conducting several (presently planned as three) demonstrations of subsurface barrier technologies for confining leakage from Hanford Site tanks. The strategy includes a step-wise evaluation process for selecting concepts for demonstration. The intent of this step-wise process is to re-evaluate iteratively the benefit and cost-effectiveness of the various options as new information is developed. Technologies that are most likely to be successful in full-scale applications at Hanford Site tank farms will be selected for demonstration on a reduced scale at an uncontaminated test site. Results from successful reduced-scale demonstrations should provide all necessary information for scaling the technology to applications in Hanford Site tank farms.

3.1 INTRODUCTION

The overall goal of the TWRS Subsurface Barriers Demonstration Project is to demonstrate several subsurface barrier system concepts and installation configurations to support potential scale-up and implementation. This effort will be focused on field demonstrations conducted by contractors in a reduced scale ("subscale") relative to tank farm implementation. The subscale field demonstrations will be conducted at an uncontaminated location at the Hanford Site as documented in draft *Tank Waste Remediation Systems Subsurface Barriers Test Site* (Karwoski 1994). Demonstration tests will be conducted in a manner resulting in no significant impact to the environment (e.g., nonhazardous materials and chemicals will be used).

The demonstration approach will also be consistent with draft *Regulatory Assessment and Permitting Strategy for the Use of Underground Barriers at the Hanford Site* (Smith 1994). That is, the scale-up of the concepts to be demonstrated for application to Hanford Site tank farms should not introduce new regulatory permitting issues whose resolutions could adversely impact schedules for retrieving tank waste. Demonstrations of the following three basic concepts are planned, contingent upon the determination that the three satisfy selection criteria to be established in the RFP:

- Injected or infused material barriers
- Cryogenic barriers
- Desiccant barriers.

These barrier concepts may be installed in one of two basic configurations: (1) close-coupled, (i.e., designed to provide confinement around a single tank), or (2) stand-off, i.e., designed to provide confinement around an entire tank farm.

The requirements and specifications for the subscale field demonstrations defined in Section 4.0 of this document are based on establishing the ability of selected concepts to meet expected functions and requirements for implemented subsurface barriers as documented in draft *Functions and Requirements for Subsurface Barriers Used in Support of Single-Shell Tank Waste Retrieval* (Lowe 1994a). The specific test conditions are based on conservative assumptions to ensure that the various system elements will be subjected to the necessary design-basis conditions. The data resulting from the subscale field demonstrations are intended to allow a scale-up analysis and support an implementation decision (i.e., there should be little uncertainty left after the analysis).

The general demonstration strategy is to solicit proposals from contractors to provide work in two steps. The initial step includes conducting necessary laboratory and/or feature testing and related evaluations to ensure opportunity for a successful field demonstration. Some of these pre-demonstration activities are specified; others may be proposed by the contractor. These pre-demonstration activities include preparation of detailed demonstration procedures and plans. Results of the testing and analysis of the plans will be used to decide if the proposed technology and approach has sufficient benefit to proceed to the optional field demonstration step.

The approach for selecting contractors will involve a selection process in which the qualifications of the contractor and the technology proposed will be evaluated against a set of criteria to be defined in the RFP. Proposals submitted by contractors must include comprehensive information regarding the proposed concepts envisioned for tank farm implementation, the status of development of supporting technologies, the proposed pre-demonstration tests and other activities, and the proposed barrier system designs and tests for the field demonstration.

It is envisioned that a minimum of one proposal for each of the three basic concepts will be selected for conducting pre-demonstration activities. The selected contractors will perform the pre-demonstration activities to support a hold point during which Hanford Site TWRS program personnel will evaluate the data and results. The TWRS program may use an expert technical panel to review the information and provide recommendations regarding those concepts considered ready for field demonstrations. The selected contractor(s) will then be authorized, at the Hanford-exercised option to be defined in each contract, to conduct the field demonstrations.

The pre-demonstration testing and evaluation will include a series of RFP-specified laboratory or feature tests and evaluations to establish basic performance data of the proposed system. The contractor will be invited in the RFP to propose and substantiate the need for additional testing determined necessary to design a successful subscale demonstration at the Hanford Site. Laboratory testing may be waived if the contractor can demonstrate that it is unnecessary. The pre-demonstration activities will also include the preparation of detailed demonstration procedures, a quality assurance plan with data quality objectives, and a health and safety plan. These documents and the test data will allow TWRS program personnel to conduct a detailed evaluation of the readiness and benefit of the demonstration approach to be used by each contractor, in accordance to evaluation criteria to be defined in the RFP. A hold point will follow completion of pre-demonstration activities for each of the concepts during which the laboratory test results, analyses, and plans will be evaluated. The evaluations will be performed in a manner to ensure that the technology is suitable and ready for the field demonstration. The TWRS program evaluators may elect not to exercise the option of the field demonstration if the results of laboratory testing show that the technology is infeasible, exhibits low cost-effectiveness, or is not adequately planned to satisfy all specifications for conducting the field demonstration, as defined in Section 4.3 of this document.

The field demonstration will involve installation of a complete sub-scale subsurface barrier system at the designated uncontaminated test location at the Hanford Site. The barrier system will be exhumed, sampled, and tested to assess variability in the quality of the barrier at different locations. The test results and report will support a final evaluation of the concept and address issues pertinent to scale-up and implementation. A conceptual design report will be provided by the contractor and will reflect the test results and address open design issues.

A number of developmental activities in the EM-50 Program are underway involving subsurface confinement systems and system elements. The programs currently conducting these activities are described briefly in Appendix B. contractors are encouraged to contact the EM-50 programs for the latest information regarding the technology development activities. To ensure success and no duplication of effort, TWRS program personnel will review progress and results in the EM-50 Program in parallel with the demonstration project. A final review and evaluation will occur during the hold point following the pre-demonstration activities. The EM-50 activities and results will be considered and reflected in the subscale field demonstration design and planning as appropriate.

The following interim schedule requirements for the demonstration have been established based on supporting milestone commitments incorporated January 25, 1994 into the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994):

- 10/95 - Complete selection process and begin contractor activities
- 02/96 - Complete pre-demonstration tests and evaluations
- 03/96 - Complete TWRS evaluation (hold point) and authorize demonstrations
- 03/96 - Begin field demonstration construction/testing
- 01/97 - Complete field demonstration testing
- 03/97 - Issue final field demonstration reports.

Section 4.0 of this document provides the detailed requirements, specifications, rationale, and verification for all of the planned contractor demonstration activities. The following sections provide a summary of the major demonstration activities both for the contractors and the TWRS program.

3.2 QUALIFICATION

The qualification process involves the review, evaluation, and selection of contractor proposals for the demonstrations. A two-part proposal submittal evaluation and selection process will be followed. Technical and cost proposals will be required first, followed later by revised technical and cost proposals for those meeting minimum criteria. The technical proposals will contain comprehensive information regarding the proposed subsurface barrier system and the approach for the field demonstrations. The following items are specified.

- **System Description** - A comprehensive description of the complete subsurface barrier system envisioned for implementation in the tank farms will be required. Subsystems include the installation equipment; the barrier materials or soil conditioning; and the installed configurations of the confinement barrier, verification, monitoring, maintenance, and related supporting equipment or systems. Soil flushing is an example of a related supporting system in which the subsurface barrier technology requires removal or cleaning of contaminated soil to ensure overall effectiveness of the technology. Descriptions and quantities of all equipment, components, and materials comprising the subsystems along with estimated costs will be required. Further, the contractors' estimates of costs to perform the detailed design, construction, operation, and maintenance will be required.

- **Technology Status** - The technical bases and foundation of the technologies used along with supporting calculations will be required. Discussion will address the previous studies, tests, and field applications to establish the level of confidence in the proposed system as well as the uncertainties.

- **Pre-demonstration Test Plan** - The contractor's proposed laboratory or feature tests, evaluations, and analyses to be conducted in the pre-demonstration period will be described. The contractor's test plan will address the minimum activities specified. Further, it will address and substantiate the need for those additional activities the contractor considers necessary to support a total demonstration scope that will minimize remaining uncertainty in the proposed concept. The discussion in the pre-demonstration test plan will focus on a scope and sequence addressing any uncertainties established in the technology status discussion.

- **Field Demonstration Plan** - The proposed field demonstration subsurface barrier system will be described. Any equipment that will be different than that envisioned for the full-scale tank farm concept will be identified and described. Further, the contractor will discuss the basis for not using the full-scale equipment and address any resulting effect on the tests in terms of uncertainty. The proposed tests, addressing the minimum specified activities, and any additional contractor-proposed tests, will be described. The proposed tests should address any uncertainties expected to remain following the pre-demonstration activities.

The review of Technical Proposals will be performed in accordance with the Federal and DOE Acquisition Regulations using a Source Evaluation Panel. The Source Evaluation Panel may use the input of expert technical reviewers to assess the technical data provided. The technical review process will include development and use of an independent estimate of the costs to implement the proposed subsurface barrier system concept in an actual tank farm. The independent cost estimates will be compared with the data provided by the contractors and any major differences will be identified. Contractors whose proposals meet minimum criteria will be asked to respond to questions and submit revised technical and cost proposals. They will be asked to explain their bases where major differences in cost of implementing barriers were identified. The Source Evaluation Panel will then select several (currently planned as three) contractors to perform work specified as pre-demonstration activities in the RFP. Following this work, the Source Evaluation Panel may exercise its option to select one or more of the pre-demonstration contractors to perform the proposed field demonstrations. Final selection of contractors will be based on best value to the government.

3.3 PRE-DEMONSTRATION ACTIVITIES

The general objective of the pre-demonstration activities is to perform laboratory or feature-type tests and evaluations of the selected barrier concepts. Further, the pre-demonstration activities will include detailed planning and definition of the field demonstration. The laboratory tests are structured to establish performance of certain system elements across specified ranges in test conditions (e.g., soil type, simulant waste composition, and radiation effects). The evaluations will help to establish the technical foundation of the system for implementation in the tank farms. Evaluations will focus on ensuring that the barrier system will not compromise tank integrity because of mechanical and thermal loads imposed during installation and operation. Evaluations will also focus on the physical and chemical properties of the formed barrier to aid in predicting performance. Testing may include both RFP-specified and contractor-specified work. The benefit of contractor-specified work must be fully substantiated.

3.3.1 Contractor Pre-demonstration Tasks

The specified laboratory tests will examine the compatibility of the barrier materials or soil conditioning with actual Hanford Site soil samples or surrogates. In addition, laboratory samples may be exposed to simulated tank leakage to indicate confinement capability. Evaluations will be performed as needed to support testing, overall design, and scale-up considerations. For close-coupled barrier concepts, evaluations may focus on the impact of the close-coupled system on the tank structure. For example, certain barrier material candidates may involve heating of an annulus of soil around the tank before injection or infusion of the barrier-forming material. The impact of this heating on the soil and the tank structure and contents must be carefully assessed before investing significant effort in developing those candidates. This evaluation will provide the necessary calculations, review, and assessment to determine the significance of variations in Hanford Site soil heating to barrier quality. The use of soil flushing before installing the close-coupled barrier may be evaluated as part of the total system approach. This may be advantageous given the cost of the alternative of excavating and working with highly radioactive soil and when considering site closure needs. Evaluations may also be performed to determine the response of the system to specified geological events, such as earthquakes.

Evaluations of subsurface barrier systems designed to provide confinement around entire tank farms ("stand-off" systems) may focus on determining overall geometry given established limits of mechanical and thermal loading on tank structures and other constraints such as the need to minimize soil contamination. Evaluation of the capability of soil flushing used in conjunction with the barrier to remove tank farm soil contamination and support site closure may also be performed. Evaluations may also be performed to determine the response of the system to geological events such as earthquakes.

Some level of directional drilling capability is required by many of the barrier system concepts. The close-coupled concept may require drilling very near a tank boundary. An evaluation to determine the mechanical loads in the tank structures resulting from drilling and pipe emplacement is needed and will be an important first step in developing several of the barrier concepts. Drilling and pipe emplacement also must not compromise the mechanical integrity of the 700 bore holes installed in the tank farms for monitoring purposes.

Evaluations of cryogenic barrier systems will be performed to determine the response of the system to specified geological events, the effect of the ice barrier formation (e.g., "frost heave") in terms of any physical or thermal loading on the tank structures. Startup of the cooling system in a cryogenic barrier may produce significant thermal stresses in the long lengths of cooling pipes. These stresses and their impact may need to be evaluated. The failure of a cooling pipe and the resultant leakage of the refrigerant may compromise the continuity of the frozen barrier. The means for recovery from this situation may need to be developed, evaluated, and potentially tested. In particular, the ability to reestablish the frozen barrier in the area of the leak (with the soil potentially saturated with refrigerant) may need to be established.

The contractors will submit the results of the pre-demonstration activities to TWRS in the form of a test report. Further, a revised field demonstration test plan containing detailed procedures for the subscale field demonstration will be submitted. A health and safety plan and quality assurance plan containing data quality objectives will also be submitted. These documents will serve as the contractor's final plans for continuing activities.

3.3.2 Hanford Site Pre-Demonstration Tasks

The TWRS program will provide personnel to witness selected pre-demonstration tests. This will include the necessary travel to contractor facilities. In additon, the TWRS program will provide analysis of the RFP-specified laboratory test samples. Confirmatory analyses and evaluations will be performed as required to establish acceptability of the selected concepts in terms of, fo example, tank structure loading and feasibility of soil flushing to remove contaminants.

Following the pre-demonstration tests, a detailed review and evaluation of the pre-demonstration tests results will be performed by the Source Evaluation Panel. The Source Evaluation Panel may assemble and use expert technical reviewers to assist in the evaluations and to formulate technical recommendations regarding the field demonstrations. Ongoing activities and results from the EM-50 projects developing subsurface confinement technologies will be reviewed in detail during this hold point to determine the effects, if any, that these results should have regarding continuing activities.

3.4 FIELD DEMONSTRATION

The field demonstrations will involve installation, operation, and testing of the selected sub-scale barrier systems complete with verification, monitoring, confinement, maintenance, and repair capabilities. The primary purpose of the field demonstration is to establish the ability to successfully install and operate such a system in a large scale in the Hanford Site geologic setting. Further, the demonstration barriers will be subjected to simulated tank leakage to test performance. Portions of the field demonstration barriers will be excavated to validate installation and performance. The TWRS program field personnel will install separate instrumentation to provide independent overchecks of the proposed systems and validation of performance. Upon completion of the field demonstration, the contractors will provide a final test report including a conceptual design for implementing the concept in Hanford Site tank farms.

3.4.1 Contractor Field Demonstration Tasks

Close-coupled barrier systems will be installed around a reduced-scale tank mockup structure provided and installed by the contractor. The nominal mockup tank dimensions will be 3 m (10 ft) in diameter, 3 m (10 ft high), and buried in the test site soil so that the top of the tank is at or near grade. The tank structure will be equipped with the necessary systems to measure the effects of installing the barrier and other specified test events. Hanford Site personnel will also install various devices and instrumentation to allow measurement of leakage of tracer gas during integrity verification testing, and leakage/migration of the leakage simulant (water with tracer). The field tests will focus on subjecting the installed confinement barrier to the specified events simulating postulated tank leak accidents. The installed monitoring system will be used to determine confinement performance and other parameters. Portions of the barrier will be excavated following the tests to examine the materials or soil conditions and verify successful installation. Laboratory analyses will be performed at the Hanford Site on collected samples of the barrier to measure the variability in quality and the degree of penetration by the leakage simulant.

Tank farm (stand-off) systems will be installed in the field demonstration in a geometry that meets the following criteria.

- Provide confinement around an imaginary reduced-scale tank [3-m (10-ft) diameter, 3-m (10-ft height), 3-m (10-ft base depth)]. An actual tank must be installed, if necessary, to evaluate conformance to all specifications identified in Section 4.0.

- The basic geometry of the barrier shall be "U", "V", or open-top box in shape to allow for the specified simulated tank leakage testing.

- If the barrier system and materials are such that cold joints would exist in the installed full-scale geometry, a minimum of three cold joints shall be present in the demonstration barrier.

- The installation and operation equipment and modes of operation shall be "full-scale" (i.e., as though the installation was taking place in an actual tank farm), to the extent practicable. Deviations from the use of full-scale equipment will require conclusive justification that the full-scale equipment/operation is not necessary or appropriate given scale-up considerations.

- Access features such as polyvinyl chloride (PVC) pipes shall be installed by the contractor as specified to support subsequent integrity verification and leak monitoring tests.

The field demonstration will focus on subjecting the installed confinement barrier to the specified events simulating postulated tank farm leak accidents. The installed monitoring equipment will be used to determine confinement performance and other parameters. Portions of the barrier will be excavated following the tests to examine the materials and soil conditions and verify successful installation. Testing of collected samples will be performed by Hanford Site personnel.

Upon completion of all field demonstration activities, the contractors will prepare and submit draft and final field demonstration reports. Each report will provide conclusive discussion of the complete demonstration sequence of tests, evaluations, and results. The final reports will address the uncertainties that were resolved and the basis for the resolution and address any remaining issues regarding scale-up and implementation of the proposed concept. Each report will contain a conceptual design for a tank farm application for each of the demonstrated concepts. The conceptual designs will reflect the knowledge gained in the demonstrations to further substantiate the validity of the concepts for application in the Hanford Site tank farms.

3.4.2 Hanford Site Field Demonstration Tasks

The TWRS program will provide field support to the contractor testing activities as defined in the draft *Tank Waste Remediation Systems Subsurface Barrier Test Site*, (Karwoski 1994). Hanford Site personnel will witness the tests and perform confirmatory sampling and testing on a noncontrolling basis. Following installation and operation of the demonstration barrier and completion of the tests, portions of the barrier will be excavated by the contractor under the direction of Hanford Site personnel for sampling and inspection by Hanford Site personnel.

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4.0 REQUIREMENTS AND SPECIFICATIONS

This section defines requirements and specifications to be considered as bases for an RFP to conduct subscale field demonstrations of subsurface barrier technologies for confining leaks from Hanford Site SSTs. The subscale field demonstrations will be conducted in a contamination-free site located approximately 16 km (10 miles) from the Hanford Site tank farms. This section presents three sets of requirements: (1) general qualification requirements, which will be used to ensure that both the technology and the contractor meet minimum requirements; (2) pre-demonstration requirements, which will be used to qualify the field demonstration approach and to ensure that adequate data and plans are available to evaluate the soundness of the final plans and design of the field demonstration; and (3) field demonstration requirements, which will be used to ensure that the field demonstration is conducted safely and in a manner that provides all necessary information to proceed to full-scale demonstrations or applications or, if the field demonstration is unsuccessful, to cease work on the technology in regard to the Hanford Site tank farm application. The rationale for each requirement, the specification to be met, and the method Hanford Site personnel will use to verify conformance to each specification are provided.

4.1 GENERAL QUALIFICATION REQUIREMENTS AND SPECIFICATIONS

This subsection defines 10 general requirements and specifications for Hanford Site applications of subsurface barrier technologies. These requirements and specifications address feasibility, implementability, safety, cost-effectiveness, compliance with regulations, contractor qualifications, and other important factors. The specifications included in this section must be met by the contractor through the performance of calculations and through descriptions of capabilities and offered technology. These calculations and descriptions will serve as bases for an evaluation of the qualifications of the technology and the contractor by a Source Evaluation Panel. The Source Evaluation Panel will also evaluate each contractor's qualifications regarding the technical approach to meeting the specifications. The evaluation will be based on criteria to be listed in the RFP.

4.1.1 General Qualification Requirement No. 1

Requirement: Subsurface barrier technologies to be demonstrated must be (1) already proven in field applications similar to or larger in scale than the planned Hanford Site subscale barrier field demonstrations, and/or (2) already proven through a mature laboratory development program, and/or (3) based on well-understood scientific principles and defensible calculations that clearly show the benefit and likelihood of success of the barrier concept.

Rationale: The scope and schedule of the TWRS program does not provide latitude for conducting research and development. Various programs under DOE's EM-50 Division provide mechanisms for funding research and development on subsurface barriers. Certain EM-50 technologies may be ready for demonstration at the Hanford Site if all aspects of a given technology are sufficiently developed. These aspects include materials properties, emplacement methods, verification methods, and monitoring methods. Relevant EM-50 activities are summarized in Appendix B.

Specification: The contractor must present information in the technical proposal that provides proof that the proposed barrier is ready for demonstration and is likely to be successful in the Hanford Site application.

Proof must be provided for each of the following requirements:

- Provide a summary of previous laboratory and field work, including quantitative and qualitative data on barrier hydraulic conductivity, porosity, nitrate ion diffusivity, radiation effects, and chemical reactivity. Best scientific estimates of the average and ranges of each of these properties are to be given if quantitative data are not available. Bases for the estimates are also required.

- Provide a summary description of the technology and equipment that would be used to emplace, verify, and monitor a stand-off barrier beneath a hypothetical tank farm containing sixteen 23-m (75-ft) diameter tanks on 30-m (100-ft) centers in a 4 x 4 array or a close-coupled barrier around a single 23-m (75-ft) diameter tank. An estimate of the time required to complete these activities for the described tank farm must be provided.

- Provide contractor qualifications regarding experience and credentials in barrier material science, particularly involving materials used in barrier technology, and use of barrier emplacement, verification, and monitoring technologies in field applications similar to those proposed for the Hanford Site sub-scale demonstration. Qualifications should include project descriptions, personnel resumes, and references.

- For proposers of close-coupled barrier systems, calculations must be performed to show whether a perfectly installed barrier, including any soil that exists between the barrier and the tank wall, would leak and/or absorb more than 3,800 L (1,000 gal) of 3.5 *M* tank salt solution under a 3-m (10-ft) head of liquid during a period of one year. The proposer must list all assumptions and the basis for each assumption with the calculations. Preliminary calculations performed at the Hanford Site indicate that leakage of less than the above level may not require further retrieval/recovery actions. This is a highly desirable outcome because it eliminates the high costs and risks associated with retrieval of the contaminated barrier and soils.

- For proposers of stand-off barrier systems, calculations must be performed to show whether the barrier can contain up to four 150,000 L (40,000 gal) leaks from four tanks in a single hypothetical 16-tank tank farm over a 10-year period. The proposer must list all assumptions and the basis for each assumption with the calculations. For example, the contractor must indicate the fraction of the leaked waste assumed to be absorbed by the soil porosity and the fraction that results in a hydraulic head on the barrier. Calculations must also be performed to show if the barrier will accommodate the use of soil flushing to recover at least 95 percent of the non-sorbing salts released in the combined leaks, including material absorbed by the barrier. Soil flushing entails the addition of water to contaminated soil and the subsequent recovery and treatment of the contaminants dissolved in the water. Preliminary calculations by Hanford Site personnel indicate that the hypothetical leakage and subsequent cleanup to this level may not require further retrieval/recovery actions to ensure that drinking water standards will not be exceeded. The contractor may choose to describe other methods of recovering or immobilizing approximately 95 percent of the leaked non-sorbing salt solution if soil flushing is not compatible with the proposed technology.

- If calculations show that the contractor's close-coupled or stand-off technology (including desiccant barrier technology) is inadequate for containing leaks and/or accommodating soil flushing to the levels specified above, the technology may still have merit if it substantially limits the total volume of contaminated soil and barrier materials. This would reduce the cost of mechanical retrieval of the contaminated soil and barrier. In this case, the contractor must provide assumptions, bases, and calculations of the volume of contaminated Hanford Site soil and barrier materials that would result 10 years after the occurrence of four 150,000 L (40,000 gal) leaks, with and without the presence of a barrier. Contaminated soil and barrier materials are, in this context, all soil and barrier materials that have been in contact with waste liquid from the tanks.

  The contractor should assume that the four leaking tanks would leak a maximum of 150,000 L (40,000 gal) each at a rate of 4 L/min (1 gal/min) without a barrier. In the case of close-coupled barriers, the contractor should assume that each of the four tanks at issue is exposed to a head of 3 m (10 ft) for one year during tank waste retrieval actions.

Note: All calculations must be based on soil properties and conditions provided in or inferred from Table 4-1.

Please note that data provided in this table are from samples collected from different locations on the Hanford Site. Soil properties as a function of location and depth vary widely at the Hanford Site.

Table 4-1. Typical Properties of Hanford Site Soils (Tallman et al. 1979).

Well Number	Well Depth (ft)	Textural Description	% Pebbles & Cobbles	% Sand					% Silt & Clay	% $CaCo_3$
				Very Coarse	Coarse	Medium	Fine	Very Fine		
299-W11-1	31	Slightly silty pebbly very coarse to coarse sand	21.6	22.6	19.4	12.4	8.1	5.2	10.8	1.6
699-44-64	70	Silty sandy medium to fine pebble	43.8	10.3	18.7	10.8	5.8	3.5	7.2	1.3
299-E27-5	220	Coarse to fine sand	0.6	4.8	26.5	44.6	13.7	4.1	5.6	0.9
299-E28-15	120	Slightly silty coarse to medium sand	3.5	11.6	22.9	30.5	13.2	7.1	11.2	2.4
299-E28-6	45	Very coarse to medium sand	2.4	16.5	47.9	19.1	5.9	4.6	3.7	1.7

Sediments at the Hanford Site exhibit the following typical properties:

- Moisture Content: 2 to 15 vol%
- Porosity: 10 to 40%
- Effective Porosity: 10%
- Hydraulic Conductivity: 430 to 760 m/day (1,400 to 2,500 ft/day)
- Anisotropy: 10 to 15:1
- Silt to Clay Ratio: 10:1.

A description of the geology of the Hanford Site is provided in Appendix A. Variations in Hanford Site sediments may exhibit hydraulic conductivities orders of magnitude lower than the typical values shown above.

Verification: The Source Evaluation Panel will review the contractor's response to this requirement in the technical proposal and determine if adequate proof of the state of development and merit of the technology are provided. Similarly, the contractor's qualifications to conduct the demonstration will be evaluated.

4.1.2 General Qualification Requirement No. 2

Requirement: Methods used to install and use subsurface barriers must result in minimizing quantities of secondary waste requiring disposal. They must also be consistent with DOE's policy to limit worker exposure to hazardous chemicals and radionuclides to levels that are ALARA.

Rationale: A secondary reason for using subsurface barriers is to minimize the quantity of contaminated soil that will result from leaks caused by sluicing wastes from the tanks. Such contaminated soil may require exhumation and disposal if quantities exceed allowable limits. Disposal costs alone will probably exceed the current costs of disposal of mixed waste at the Hanford Site (approximately $1,000 per drum) because of the complexity of dealing with the high radioactivity associated with the waste. Exhumation and handling costs probably will be much higher than disposal costs.

The high levels of radioactivity in contaminated soils may dictate that robotic or remotely-operated methods be used for installing barriers, especially when contaminated spoils are produced. Therefore, quantities of newly created contaminated materials resulting from drilling, boring, or other means of installing the barrier must be minimized. Emplacement methods must be adaptable to robotic or remote operations whenever contaminated soils may be generated.

Specification: The contractor must present information in the technical proposal regarding estimated quantities of spoils that will be generated during all phases of barrier installation, verification, monitoring, and maintenance. Estimates must be divided into the following categories: (1) 0 to 6 m (0 to 20 ft) from ground surface and (2) below 6 m (20 ft) from ground surface. Estimates must be based on a tank farm containing sixteen 23-m (75-ft) diameter tanks in a 4 x 4 array. Estimates for close-coupled barriers must be based on 16 individual tank barriers. [Note: the subscale demonstration will not be conducted on 3-m (10 ft) diameter tanks.]

Verification: A Source Evaluation Panel will review information provided by the contractor in the technical proposal as part of its mission to assess which contractors and technologies are qualified to produce a full-scale barrier that is cost-effective, feasible, implementable, and in compliance with regulations.

4.1.3 General Qualification Requirement No. 3

Requirement: Subsurface barriers must be cost-effective relative to other options, including mechanical retrieval techniques that do not employ water to aid in retrieving waste from the tanks and, hence, do not cause leakage to the soil.

Rationale: The successful demonstration of subsurface barriers will enable the use of traditional, well-proven sluicing techniques for retrieval of wastes from the tanks. The combined subsurface barrier and traditional sluicing option may result in lowest overall risk to workers, the public, and the environment, and/or lowest cost when compared to other options.

Specification: In the technical proposal the contractor must provide an estimate of the labor hours and costs of a stand-off barrier under a hypothetical tank farm containing sixteen 23-m (75-ft) diameter tanks on 30-m (100-ft) centers in a 4 x 4 array. contractors proposing close-coupled barriers must provide an estimate of the costs of installing 16 close-coupled barriers around sixteen 23-m (75-ft) diameter tanks. The contractors must assume the following: (1) no soil contamination exists at present in the tank farm, (2) barrier monitoring and maintenance must be conducted for 10 years following verification of barrier integrity, and (3) a 5 percent escalation in labor and material costs each year. The contractor must provide a breakdown of labor hours and material costs for each year beginning with planning, design installation, verification, and ending with 10 years of monitoring and maintenance. Costs for contaminated soil flushing or soil retrieval following the 10-year period of monitoring and maintenance should not be included.

Verification: The Source Evaluation Panel will review cost and labor hour estimates provided in the technical proposal for realism. Comparisons of proposer's costs and projected volumes of contaminated soil/barrier materials will be made. Unrealistically biased costs will be considered evidence of the contractor's lack of understanding of the technology and Hanford Site needs.

4.1.4 General Qualification Requirement No. 4

Requirement: The barrier system must not employ chemicals and/or other materials whose use or leakage below the ground surface would result in creation of a Washington State Dangerous Waste according to Washington Administrative Code (WAC) 173-303, violation of a groundwater standard, or whose leakage to the air could violate an air quality standard.

Rationale: Retrieval of hazardous materials beneath the tanks will be very expensive unless the materials are readily amenable to cleanup by soil flushing, soil vapor extraction, or other in-situ method. Violation of air and water quality standards is not acceptable.

Specification: The contractor's Technical Proposal must identify the names and quantities of all materials and chemicals planned for use in any application of the technology at the

Hanford Site, including chemicals that are intended to be contained at all times, but that could conceivably leak to the air or into the ground. Material Safety Data Sheets for all chemicals used in the technology must be provided.

The contractor must certify in the technical proposal that, to the best of his or her knowledge, application of the technology at the Hanford Site will not create a Washington State Dangerous Waste or violate air and/or water quality standards that apply at the Hanford Site. In the absence of this certification, the contractor must discuss the history and past successes in obtaining waivers or exemptions from regulations that control the similar use of all hazardous chemicals employed in the contractor's technology.

Verification: The Source Evaluation Panel will review the certification and/or discussion regarding the use of hazardous chemicals.

4.1.5 General Qualification Requirement No. 5

Requirement: The barrier emplacement process and the barrier must not adversely impact present and future tank farm operations.

Rationale: Essential tank farm operations include (1) monitoring tank conditions through ports at the top and along side the tanks, through vertical wells between tanks and outside tank farms, and at instrumentation stands on top of or adjacent to tanks; (2) replacing failed equipment, including 15-m (50-ft) long pumps and sluicers using boom cranes that require access between tanks; (3) obtaining core samples of waste using a sampling vehicle that drives on top of the tank; and (4) retrieving tank waste using devices such as a 21-m (70-ft) high mechanical waste retrieval structure that may straddle an entire 23-m (75-ft) diameter tank.

Specification: The contractor's technical proposal must include a discussion of the ability of the contractor's technology to accommodate tank farm access and operation of each of the four items/activities described above.

Verification: The Source Evaluation Panel will review the description of the technology in the technical proposal to ensure that adequate access exists for the described equipment and activities.

4.1.6 General Qualification Requirement No. 6

Requirement: Emplacement and maintenance of the barrier must not adversely impact tank integrity. Barrier chemicals must not weaken the concrete structure of the tank.

Rationale: Barrier emplacement and maintenance activities that result in cracking the concrete encasement around the tanks and/or the steel tank itself may cause new leaks and/or exacerbate existing leaks.

Specification: The barrier emplacement process and subsequent maintenance will not result in exceeding any of the following limits:

- A maximum concrete wall temperature of 120 °C (250 °F) (hold)
- A maximum rate of concrete wall temperature change of 7 °C (20 °F)/day (hold)
- A live load of [reserved] on the wall or floor of the tank
- Total live loads of 50,000 and 100,000 Kg (50 and 100 tons) on the domes of 6-m (20-ft) and 23-m (75-ft) diameter tanks, respectively.

The contractor must estimate the effects of the barrier emplacement process regarding each of the four parameters above and include the estimates in the technical proposal.

Verification: The Source Evaluation Panel will ensure conformance of the contractor's estimated temperatures and live loads to the above limits.

4.1.7 General Qualification Requirement No. 7

Requirement: The integrity (leak-tightness) of the barrier must be verified before its use as a tank barrier to supporting sluicing operations.

Rationale: Soils around tanks probably are heterogeneous and variations in the quality control of the barrier emplacement procedure are likely to occur. These variabilities may result in leaks and/or areas of high hydraulic conductivity in the barrier.

Specification: The contractor must describe a feasible method for verifying the leak-tightness of the barrier in the technical proposal.

Verification: The Source Evaluation Panel will evaluate the feasibility of the verification method.

4.1.8 General Qualification Requirement No. 8

Requirement: Barriers must be repairable.

Rationale: A barrier system that leaks probably will result in very high costs for remediating contaminated soils.

Specification: The contractor must provide a detailed description of feasible methods to repair and verify the repair of an inadequately installed barrier in the technical proposal.

Verification: The Source Evaluation Panel will assess the feasibility of the repair methods proposed.

4.1.9 General Qualification Requirement No. 9

Requirement: The design of the barrier system must not preclude the ability to remediate excessive contamination that has leaked from the tanks.

Rationale: The primary purpose of a subsurface barrier is to support the use of sluicing as the reference tank waste retrieval technology and thereby help to maximize the level of waste retrieval and enhance the probability of meeting a target limit of at least 99 percent removal. Please note the distinction between 99 percent removal from the tank in this general qualification requirement and 95 percent removal from contaminated soil in General Qualification Requirement No. 1. The barrier is intended to stop the migration of new and existing leaks and to facilitate cleanup, if necessary, using in-situ methods, such as soil flushing, where possible. The amount of residual contamination allowable in the soil following cleanup has not been determined but is roughly estimated to be equivalent to about 3,800 L (1,000 gal) of saturated salt solution per tank.

Specification: The contractor's technical proposal must include a description of feasible methods for cleaning up a hypothetical 150,000-L (40,000-gal) leak from a single tank *if* the contractor proposes a stand-off barrier. The potential for and impact of forming barrier depressions resulting in "lakes" of contaminated liquid that will not drain must also be considered and evaluated in the description of the cleanup method.

Verification: The Source Evaluation Panel will assess proposed methods described in the technical proposal and the likely costs of achieving the required degree of cleanup.

4.1.10 General Qualification Requirement No. 10

Requirement: The applied, full-scale barrier must remain leak-tight for as long as 30 years to support retrieval and soil flushing or contaminated soil removal operations.

Rationale: Because of high levels of contamination and/or low hydraulic conductivities, certain Hanford Site soils may require long times to clean by soil flushing or through use of mechanical retrieval methods.

Specification: The contractor must provide a detailed argument supporting the 30-year leak-tightness requirement in the technical proposal.

Verification: The Source Evaluation Panel will review the adequacy of the argument.

4.2 PRE-DEMONSTRATION REQUIREMENTS AND SPECIFICATIONS

This subsection defines 11 requirements and specifications to be met by the contractor. These requirements and specifications regard the technical approach to conducting the field demonstration. The contractor's responses to the first eight requirements will be considered together with the contractor's responses to the 10 general requirements in Section 4.1. These responses will serve as the bases for evaluating the qualifications of the contractor and the proposed technology. The evaluation of qualifications will be based on criteria to be defined in the RFP.

Contracts to perform pre-demonstration activities will be awarded to several (currently planned as three) contractors who the Source Evaluation Panel determines to be qualified and who offer the most beneficial and cost-effective technologies in accordance to the criteria defined in the RFP. One or more contracts may be awarded in each of the three barrier areas of interest: injected or infused material barriers, cryogenic barriers, and desiccant barriers. Less than three awards may be made based on the relative technical benefit and proposed costs of the work. Pre-demonstration Requirements No. 9, 10, and 11 described in this section will be met by awardees of pre-demonstration contracts.

The approach to be used by the Source Evaluation Panel in selecting awardees is the following seven step process.

1. The contractors will submit separate technical and cost proposals. The cost proposals will include fixed price costs for

    a. conducting the work regarding requirements 9, 10, and 11

    b. for conducting the work defined in Section 4.3.

2. The Source Evaluation Panel will determine which contractors are qualified.

3. Qualified contractors will be provided a letter by the contracting officer including questions and a request for clarification of their technical proposals. The letter will also request preparation of best and final cost proposals.

4. The Source Evaluation Panel will re-evaluate technical merit and cost according to the criteria to be specified in the RFP.

5. Contracts will be awarded for performing the pre-demonstration activities defined in requirements 9, 10, and 11.

6. Once the pre-demonstration activities are completed, the same or a new Source Evaluation Panel will evaluate the results against criteria to be defined in the RFP.

7. Awardees of the pre-demonstration contracts who meet these criteria will be authorized to conduct the field demonstration in accordance to the requirements and specifications described in Section 4.3. Authorization to proceed will be exercised at the option of the TWRS program.

4.2.1 Pre-demonstration Requirement No. 1

Requirement: The field demonstration barrier must be constructed in a basin-like configuration to allow leak testing with water.

Rationale: The purpose of the applied barrier is to contain leaks from tanks within the confines of a barrier basin.

Specification: The field demonstration barrier must be constructed in the shape of a U, V, or open-top box. Close-coupled barriers must enclose and fully contact the walls and base of a nominal 3-m (10-ft) diameter by 3-m (10-ft) high buried steel tank to be provided by the contractor. contractors can propose a larger tank if they also provide the rationale for doing so. Stand-off barriers must underlie an imaginary tank of the same dimensions and be able to contain a 3-m (10-ft) head of water. contractors must describe their subscale demonstration barrier designs, including dimensions, in their technical proposals.

Verification: The Source Evaluation Panel will review the barrier design for soundness and conformance to the specification.

4.2.2 Pre-demonstration Requirement No. 2

Requirement: The size of the field demonstration barrier must be sufficient to enable demonstration of barrier emplacement equipment on a full-scale or nearly full-scale basis.

Rationale: A primary purpose of the field demonstration is to provide proof of whether the barrier emplacement technology will be effective in a full-scale application.

Specification: The nominal 3-m (10-ft) high by 3-m (10-ft) diameter subscale demonstration tank or imaginary tank is sized to ensure the use of full-scale or nearly full-scale emplacement equipment. In the technical proposal the contractor must list and describe all emplacement equipment, including instrumentation to be used in the field demonstration. Any such equipment that would not be used in a full-scale application must be noted and arguments presented on each as to why the field demonstration equipment will yield results representative of full-scale equipment. A brief description of the barrier installation procedure involving this equipment must also be provided in the technical proposal.

Verification: The Source Evaluation Panel will review equipment proposed for the field demonstration, and evaluate the soundness of arguments on the ability to scale results from the field demonstration to a full-scale application.

4.2.3 Pre-demonstration Requirement No. 3

Requirement: The field demonstration barrier must be constructed so that joints between barrier segments are covered with water during leak testing in order to evaluate the leak-tightness of joints. This requirement applies only to barrier concepts involving emplacement of barrier segments.

Rationale: Joints may be the most leak-prone area of the barrier.

Specification: At least three joints between barrier segments (if present in the full-scale application) must be covered with water during leak testing. Simulated tank failure discussed in Section 4.3 will expose joints to water in the case of close-coupled barriers. At least one joint must be created after allowing at least seven days to elapse between installing the adjacent barrier segments. The contractor will have the option of sealing any or all joints, where practical, in accordance with the barrier concept. If sealing joints is contemplated, the method must be described in the technical proposal. This specification does not apply to desiccant barriers and cryogenic barriers designed to dry or freeze leaked material as opposed to creating a basin for confining liquids. The contractor must describe the plan and design for creating joints, where applicable, in the technical proposal.

Verification: The Source Evaluation Board will evaluate the planned approach for creating joints that are representative of the full-scale application.

4.2.4 Pre-demonstration Requirement No. 4

Requirement: The subscale barrier system must not employ chemicals and/or other materials whose use or leakage below the ground surface would result in creation of a Washington State Dangerous Waste according to WAC 173-303, or whose leakage could violate an air or groundwater quality standard.

Rationale: Retrieval and disposal of hazardous materials, including contaminated groundwater, following the subscale demonstration, would be very expensive. Violation of State and Federal standards is not acceptable.

Specification: In the technical proposal, the contractor must identify the names and quantities of all materials and chemicals planned for use in the field demonstration, including chemicals that are intended to be contained at all times, but that conceivably could leak to the air or into the ground. The contractor must certify that the barrier system will not create an RCRA violation or a Washington State dangerous waste and agree to remove and dispose any barrier materials subsequently found to violate the certification, at his or her expense. The contractor must also explain any variance between the use of chemicals in a tank or tank farm application of the technology and the use of chemicals planned for the field demonstration.

Verification: The Source Evaluation Panel will verify that the contractor has provided the certification and review discussion on any variance in the use of chemicals.

4.2.5 Pre-demonstration Requirement No. 5

Requirement: Installation or maintenance of the barrier must not adversely impact tank integrity.

Rationale: Barrier installation or maintenance that results in cracking the concrete encasement around the tanks or the steel tank itself may cause new leaks and/or exacerbate old ones.

Specification: The full-scale barrier emplacement process will not result in exceeding any of the following limits:

- A concrete wall temperature of 120 °C (250 °F) (hold)
- A rate of concrete wall temperature change of 6.7 °C/day (20 °F/day) (hold)
- A live load of (reserved) on the wall or floor of the tank
- A live load of 50,000 to 100,000 Kg (50 to 100 tons) on the domes of 6-m (20-ft) and 23-m (75-ft) diameter tanks, respectively.

The contractor must provide plans in the technical proposal, for installing thermocouples, strain gauges, and other instruments to measure stresses and displacement of soil at the edge of the subscale tank. Tilt meters or similar devices may be used to measure soil displacement around the tank. The plans must include identification of the number and type of each instrument and arguments that support the adequacy of the plan and sensitivity of the instruments for measuring the physical and thermal stresses on the tank.

Verification: The Source Evaluation Panel will review the plan for soundness and adequacy in measuring physical and thermal stresses. The TWRS program may exercise its option to install instrumentation to verify contractor measurements.

4.2.6 Pre-demonstration Requirement No. 6

Requirement: The time required to install, test, and evaluate the subscale field demonstration barrier must be consistent with *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestones and other key Hanford Site decision points.

Rationale: The lack of availability of information on the feasibility and effectiveness of subsurface barrier technologies when key TWRS decisions must be made may result in a management decision to commit all retrieval-related resources to the development of mechanical waste retrieval technologies that do not rely upon sluicing.

Specification: The contractor must agree in a statement to be included in the technical proposal to complete installation of the demonstration barrier by August 15, 1997 when simulated leak-testing of the barrier is scheduled to begin. This schedule assumes that the Kaiser Engineers Hanford contracting officer will authorize installation work to begin on or before March 15, 1996.

Verification: The Source Evaluation Panel will review the contractor's acceptance statement and verify commitment to the schedule.

4.2.7 Pre-demonstration Requirement No. 7

Requirement: Five vertical pipes must be embedded in the soil area confined by the subscale barrier to serve as wells for addition, monitoring, and removal of leak-test water. (Note: this requirement does not apply to close-coupled barriers.)

Rationale: Pipes will facilitate addition and removal of leak-test water, and observing the depth of water used for leak testing.

Specification: A 15-cm (6-in.) Schedule 40 PVC pipe must be inserted vertically into the deepest area confined by the barrier. The upper portion of the pipe must be machined with normal pipe threads (NPT) and must extend .6 to 1.0 m (2 to 3 ft) above the ground surface. The lower portion of the pipe must extend to within 5 cm (2 in.) of the upper surface of the barrier. The lower .7 m (24 in.) must also be fitted with a .7-m (2-ft) long, 40 slot continuous wrap or equivalent slotted PVC screen with a bottom cap to prevent sanding of the pipe while pumping test water from the confined area. A Colorado silica sand filter pack must be placed from the bottom of the boring to .7 m (2 ft) above the top of the screen. Four additional 15-cm (6-in.) PVC pipes with NPT at their tops must be inserted into holes augured to within 15 cm (6 in.) of the barrier surface. The pipes, open at the top and bottom, will be used for water depth measurements. The contractor and Hanford Site personnel will jointly select the location for the contractor's installation of these pipes. In the technical proposal, the contractor must identify all restrictions regarding the time of installing the pipes, their locations, and the use of up to 23,00 L (6,000 gal) of water containing sodium bromide as a tracer.

Verification: The Source Evaluation Panel will evaluate the reasonableness of any restrictions identified.

4.2.8 Pre-demonstration Requirement No. 8

Requirement: Barrier integrity must be verified before it is used as a tank-leak barrier.

Rationale: A barrier system that leaks probably will result in high remediation costs involving recovery and treatment of contaminated soils.

Specification: Hanford Site personnel will add a tracer gas such as sulfur hexafluoride (SF_6) through the deepest vertical PVC pipe immediately after stand-off barrier installation activities are completed. The contractor will install eight sections of 15-cm (6-in. PVC) Schedule 40 pipe below the barrier at locations jointly selected by the contractor and Hanford Site personnel. The contractor will seal the pipe annulus along its entire length to prevent annular gas leakage. The contractor must describe the proposed sealing method in the technical proposal. The pipes will extend to the surface and be open at both ends. They will be used by Hanford Site personnel for extraction of gas samples. The contractor must identify all restrictions placed on the installation and location of the sampling pipes and the use of SF_6 as a tracer gas. For cryogenic barriers that are not designed for leak-tightness, the contractor must describe in the technical proposal, how verification will be made that the subscale barrier will not leak before leak-testing with water. For close-coupled barriers, the contractor must pressurize the tank to a pressure of 4 psig using compressed air and measure the flow rate of air necessary to maintain this pressure. For desiccant barriers, the contractor must describe the method for verifying that the desiccant barrier is functioning as designed to minimize leakage.

Verification: The Source Evaluation Panel will evaluate the reasonableness of all identified restrictions regarding the tracer gas test system, the proposed method of sealing the pipe used for extracting gas samples, and the tank pressurization test. For cryogenic and desiccant systems that are not leak-tight, the Source Evaluation Panel will evaluate the soundness of the verification methods.

(Note: All preceding requirements and specifications are to be addressed in contractor technical proposals. The following three requirements and specifications in this section and the requirements and specifications in Section 4.3 are to serve as bases for preparing cost proposals. Technical issues raised by the following requirements must also be addressed in the technical proposals.)

4.2.9 Pre-demonstration Requirement No. 9

Requirement: Pre-demonstration testing in the laboratory and/or the field may be necessary to provide essential data on barrier properties. It may also be the best source of engineering data to support detailed design and planning of the field demonstration, and thereby maximize chances for success.

Rationale: Pre-demonstration testing is relatively inexpensive and can greatly improve the probability of a successful demonstration.

Specification: The contractor may propose to perform pre-demonstration testing involving Hanford Site soil or adequate simulations of Hanford Site soil where necessary to provide data to ensure the success of the barrier demonstration. Hanford Site personnel have identified several key technical issues that need to be addressed through pre-demonstration testing at contractor-supplied facilities or through adequate technical arguments based on relevant technical data/reports. These technical issues, identified in Sections 4.2.9.1, 4.2.9.2, and 4.2.9.3, are listed under three barrier categories of interest to the Hanford Site. In the technical proposal the contractor will identify each RFP- and contractor-identified data need or issue, provide a detailed description of how each data need or issue will be addressed, describe the benefit of filling the need to the successful conduct of the Hanford Site field demonstration, and provide a timetable for fulfilling RFP needs and contractor needs. In the cost proposal, the contractor will include the cost of performing the proposed pre-demonstration activities involving testing. These costs will be identified clearly as "pre-demonstration costs" in the Cost Proposal.

Verification: The Source Evaluation Panel will evaluate the technical merit of the approach and tests described for meeting RFP needs. The Panel will also evaluate the merit of all contractor-recommended testing and downgrade the proposal score when the need for such testing is poorly substantiated or when the need reflects the contractor's poor understanding of the technology. After award of the contract, Hanford Site personnel will witness tests at contractor-supplied facilities and provide evaluation of samples supplied by the contractor. Results of the testing and sample evaluation will serve as a basis for "go"/"no-go" decisions regarding the subsequent field demonstrations.

The following testing, to be specified in the RFP, is required to meet Hanford Site needs for data for evaluating the technology and/or for designing the demonstration.

4.2.9.1 Injected or Infused Material Barriers. The contractor will produce samples of soil injected or infused with proposed barrier-forming materials using three Hanford Site soils. The materials and methods used to prepare the samples must be representative of those proposed for the demonstration. Ten samples will be produced for each soil type. Each sample will be 5 $\pm$ .3 cm (2 $\pm$ 1/8 in.) diameter by 13 $\pm$ .3 cm (5 $\pm$ 1/4 in.) in length. The samples will be forwarded to the Hanford Site for testing for hydraulic conductivity, porosity, radiation resistance, and/or salt compatibility. Sample preparation methods must not employ the use of chemicals, such as mold-parting compounds, that would impact the results of the above testing. The contractor must describe the sample preparation methods in the technical proposal. Hanford Site personnel will provide up to 208 L (55 gal) of each soil to the contractor for production of samples. The contractor must provide an adequate justification if more soil is required.

4.2.9.2 Cryogenic Barriers. The contractor will conduct freezing tests on three Hanford Site soils provided by Hanford Site personnel: a coarse soil, a fine soil, and a soil obtained from the vicinity of the demonstration site. Tests will serve to evaluate the following for each soil:

- Effectiveness of the method of adding water for creating the ice barrier, if water addition is required by the contractor's technology
- Rate and degree of radial (volumetric) expansion, if any, as a function of planned temperature and water addition rates
- Rate of freezing as a function of radius from freeze pipes
- Air-filled porosity as a function of radius
- Impact of 3.5 *M* sodium nitrate solution on the integrity of the ice barrier.

Hanford Site personnel will provide up to 830 L (220 gal) of each soil type for testing at the contractor's site. The contractor must provide an adequate justification if more soil is required.

4.2.9.3 Desiccant Barriers. No Hanford Site testing needs were identified; however, the contractor may identify needs. In this event, Hanford Site personnel will provide up to 208 L (55 gal) of each soil type for testing at the contractor's site. The contractor will provide an adequate justification if more soil is required.

4.2.10 Pre-demonstration Requirement No. 10

Requirement: Barrier emplacement and maintenance operations must be consistent with DOE safety orders and standard industrial safety practices, at a minimum.

Rationale: There is no tolerance for injury to workers or harm to the public at DOE facilities.

Specification: The contractor will provide a health and safety plan and a description of codes, standards, and other safety-related provisions used to design, operate, and maintain the barrier system. The health and safety plan must be consistent with health and safety requirements submitted with the bid package. The health and safety plan must identify the most significant health and safety risks associated with each of the following hazards: electrical, physical/mechanical, chemical (including explosions and fire), and thermal hazards. Also, the health and safety plan must describe the proposed method of mitigating each of the hazards identified. The contractor should assume that the health and safety plan must be submitted for comment by Hanford Site personnel twice and that the required changes must be incorporated. The contractor's cost proposal for "pre-demonstration" work should reflect these costs associated with preparing the initial health and safety plan and two revisions.

Verification: Hanford Site personnel will evaluate the adequacy of the health and safety plan as part of the process of deciding if the option of conducting the field demonstration has sufficient merit to be exercised.

4.2.11 Pre-demonstration Requirement No. 11

Requirement: Detailed field demonstration plans and the results of pre-demonstration testing must be used as the basis for evaluating the need and value of conducting field demonstrations.

Rationale: Subscale field demonstrations will be expensive. Technologies that are not cost-effective or poorly designed should be eliminated from further consideration.

Specification: The contractor will provide final, detailed procedures for installing, verifying, and monitoring the performance of the subscale barrier in accordance with all requirements and specifications identified in Sections 4.2 and 4.3 by March 30, 1995. The contractor will also provide a final quality assurance plan that defines quality objectives for all data and information to be collected by the contractor in meeting the requirements and specifications in Section 4.2 and 4.3 by March 30, 1995. Results of all testing conducted in accordance with Section 4.2.9 will be documented in a final report to be submitted to the contracting officer by March 30, 1995. The contractor should assume that an initial draft and two revised drafts of each of these three final submittals to reflect comments provided by Hanford Site personnel will be required.

The contractor will include the costs of meeting this specification in the cost proposal under the heading "Pre-demonstration Costs."

Verification: Hanford Site personnel will evaluate the results of laboratory and other testing, the procedures, and the quality assurance plan as part of the process of deciding if the option of conducting the field demonstration has sufficient merit to be exercised.

4.3 FIELD DEMONSTRATION REQUIREMENTS AND SPECIFICATIONS

This section defines the requirements to be met by each contractor who is authorized by the contracting officer to implement field demonstration plans and procedures produced during the pre-demonstration phase of this project (see Section 4.2).

Requirement: One or more contractors should demonstrate promising subsurface barrier technologies. Subsurface barriers are intended to support sluicing alternatives as a means of preventing or minimizing the effects of tank leaks that may otherwise occur.

Specification: The contractor(s) will implement all field demonstration plans and procedures in accordance with all requirements and specifications in Sections 4.2 and 4.3. A summary of the work to be conducted is provided below:

1. The contractor will move all necessary equipment to the subscale field demonstration site described in draft *Tank Waste Remediation Systems Subsurface Barriers Test Site* (Karwoski 1994). The contractor will provide all necessary services (e.g., water, power, portable rest rooms, and potable water) to support the demonstration.

2. The contractor will install the nominal 3-m (10-ft) diameter by 3-m (10-ft) high tank, if applicable, with the top of the tank at grade, taking care to minimize disturbance of the soil surrounding the tank. The excavated soil must be covered with plastic to minimize drying prior to its use as backfill around the tank. The backfilled soil must be compacted in approximately .3-m (1-ft) lifts using a commercial soil tamper with a sheeps-foot head.

3. The contractor will install all required underground piping and instrumentation according to the specifications in Section 4.2 and calibrate instrumentation according to the requirements of the field demonstration quality assurance plan and data quality objectives.

4. The contractor will install the barrier, recording data in accordance with procedures prepared in accordance with Section 4.2.11. The cold joint must be formed by allowing at least seven days to elapse between installing two adjoining barrier segments.

5. For close-coupled barriers, the contractor will drill at least eight, 15-cm (6-in.) diameter or larger holes through the wall of the tank at locations in the lower half of the tank and at least eight, 15-cm (6-in.) diameter or larger holes in the tank bottom. Holes in the tank must be drilled into locations where barrier joints exist. At least three holes must be drilled into the cold joint.

6. Hanford Site personnel will add the tracer gas to the tank's vertical pipe and monitor for leaks for a two-week period. The contractor will repair, at his or her option, any leakage determined by tracer gas and/or pressure testing using methods (if any) described in the procedures.

7. The contractor will then fill the tank through the deepest vertical pipe with 23,000 L (6,000 gal) of water containing the specified tracer. Water should be added to the pipe at a rate that avoids overflowing. The contractor will record heights of water in the other vertical pipes at least hourly while filling the barrier basin. The tank top must be sealed to minimize evaporation.

8. Once filled, the contractor must measure water levels in the tank or pipes to a 3-cm (0.01-ft) accuracy at least once each day for 60 days. The contractor will then pump the water from the tank or basin to the maximum extent practicable (e.g., using a self-priming pump). Assume that the nontoxic water can be disposed directly to the ground surface.

9. The contractor will then remove all instrumentation, materials, and equipment as necessary and feasible to allow the tank/barrier to be excavated.

10. The contractor will then excavate the barrier over at least a three-day period, allowing Hanford Site personnel safe access to visually inspect and obtain samples of the barrier material. Excavated, injected, or infused chemical barrier pieces and the tank must be stored temporarily at the demonstration site under a secured cover of plastic sheeting and in accordance with all applicable regulations if proprietary chemicals are used or if evidence exists that the materials may qualify as a Washington State Dangerous Waste. Injected or infused chemical barrier materials formed with innocuous chemicals will be disposed by the contractor at the central landfill as bulk solid waste.

11. Hanford Site personnel will sample, analyze, and designate the temporarily stored and covered barrier materials in accordance with Washington State Dangerous Waste regulations. The contractor will dispose of all wastes determined not to qualify as Washington State Dangerous Waste to the central landfill as bulk solid waste. The contractor will dispose of all qualifying dangerous wastes to a licensed disposal facility for such wastes in accordance with all applicable regulations.

12. The contractor will prepare a draft and final report of the sequence of tests, evaluations, and results of the demonstration. The report must identify and explain which specifications identified in Section 4.2 and 4.3 were met and which were not. The report must also include a conceptual design of a full-scale barrier system, including discussion of open design issues and uncertainties, and an updated procedure and description of equipment for installing, verifying, monitoring, and maintaining the full-scale barrier. Hanford Site personnel will review the draft report and provide comments. The draft report must be modified by the contractor in response to all valid Hanford Site comments and be resubmitted.

Verification: Hanford Site personnel will witness all activities conducted by the contractor. A Hanford Site health and safety officer will inspect the demonstration site periodically to evaluate conformance to the contractor's health and safety plan. A Hanford Site quality assurance representative will periodically inspect the contractor's logbook to evaluate conformance to the contractor's data quality objectives and quality assurance plan.

5.0 REFERENCES

DOE-RL, 1993, *Tank Waste Remediation System Functions and Requirements*, DOE/RL-92-60, Draft, U.S. Department of Energy, Richland Field Office, Richland, Washington.

Ecology, DOE, and EPA, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Department of Energy, U.S. Environmental Protection Agency, Olympia, Washington.

Karwoski, W. J., 1994, *Tank Waste Remediation Systems Subsurface Barriers Test Site*, WHC-SD-WM-TI-602, Rev. D, Westinghouse Hanford Company, Richland, Washington.

Lowe, S. S., 1994a, *Functions and Requirements for Subsurface Barriers Used in Support of Single-Shell Tank Waste Retrieval*, WHC-SD-WM-FRD-011, Rev. 1, Prepared for the U.S. Department of Energy, Richland Field Office by Westinghouse Hanford Company, Richland, Washington.

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APPENDIX A

HANFORD SITE TANK BACKGROUND DATA SUMMARY

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ACRONYMS

DOE	U.S. Department Of Energy
DST	Double-Shell Tank
Ecology	Washington State Department Of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
HDW-EIS	Hanford Defense Waste - Environmental Impact Statement
HLW	High-Level Waste
LLW	Low-Level Waste
$NaNO_2$	Sodium Nitrite
$NaNO_3$	Sodium Nitrate
ORIGEN2	Oak Ridge Isotope Generation And Depletion Code (Revised)
RCRA	Resource Conservation And Recovery Act
ROD	Record Of Decision
SST	Single-Shell Tank
TRAC	Track Radioactive Constituents
Tri-Party Agreement	Hanford Federal Facility Agreement And Consent Order
TWRS	Tank Waste Remediation System
WAC	Washington Administrative Code

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A.0 INTRODUCTION

This appendix provides a summary of background information relevant to the planned subsurface barrier demonstrations. This information includes descriptions of the Hanford Site mission, its tank history, tank dimensions and other characteristics, tank waste chemical and radiological inventories, the geologic setting of the tank farms, and tank waste retrieval options under consideration. The draft *Mission Analysis Report for Demonstration of Subsurface Barrier* (WHC 1994) contains a comprehensive listing of references that should be consulted if more detailed information is needed.

A.1 HANFORD SITE MISSION AND TANK HISTORY

In 1943, the U.S. Army Corps of Engineers selected the Hanford Site near Richland, Washington to build the first plutonium production reactors and processing facilities as part of the Manhattan Project. Eight plutonium production reactors and one combination plutonium-steam production reactor were built and operated between 1944 and 1987. Chemical reprocessing plants were constructed and operated to recover plutonium and uranium from the irradiated fuel produced in these reactors. This reprocessing resulted in the accumulation of a wide variety of radioactive [i.e., transuranic, high-level, and low-level waste (LLW) as defined by U.S. Department of Energy (DOE) Order 5819.2A] and chemical waste [i.e., dangerous waste and extremely hazardous waste as defined by the Washington State Department of Ecology (Ecology) Dangerous Waste Regulations, Washington Administration Code (WAC) Chapter 173-303]. High-level and chemical liquid wastes were stored in single-shell tanks (SSTs) and in double-shell tanks (DSTs) and remain there today.

For the past four years, the Hanford Site has been dedicated to cleaning up contaminated wastes in preparation for final decommissioning and closure, which will occur during the next 40 years (Ecology et al. 1994). Waste will be retrieved from SSTs beginning in the year 2003 and ending in 2018. Wastes in one tank will be retrieved beginning in 1997 to resolve a high-heat safety issue. .

A.1.1 Tank Use

Hanford Site tanks have been used to store radioactive reprocessing waste since the 1940s. Until the early 1970s, most reprocessing waste was stored in underground, reinforced concrete, carbon-steel-lined SSTs. A total of 149 SSTs, having capacities from 210 m^3 (55,000 gal) to 3,800 m^3 (1 Mgal), have been used. In the 1960s and 1970s, radioactive strontium and cesium were extracted from wastes in some SSTs. Storage of new waste in these SSTs ceased in 1980. The SSTs contain approximately 138,000 m^3 (36.5 Mgal) of radioactive waste. The 149 SSTs are grouped into 12 tank farms. The construction and operating histories of these tank farms are summarized in Table A-1. Since 1971, underground, reinforced concrete, carbon-steel-lined DSTs have been used for storage of liquid waste. By 1981, large quantities of pumpable liquid waste had been removed from SSTs and placed in DSTs.

Table A-1. Single-Shell Tank Farm Historical Information.

Tank Farm	Number of Tanks	Tank Capacity Per Tank (m^3)	Construction period	Operation Period
200 East Area				
241-A	6	3,800	1954-1955	1956-1980
241-AX	4	3,800	1963-1964	1965-1980
241-B	12 4	2,000 210	1943-1944	1945-1978
241-BX	12	2,000	1946-1947	1948-1980
241-BY	12	2,900	1948-1949	1950-1979
241-C	12 4	2,000 210	1943-1944	1946-1980
200 West Area				
241-S	12	2,900	1950-1951	1952-1980
241-SX	15	3,800	1953-1954	1954-1980
241-T	12 4	2,000 210	1943-1944	1945-1979
241-TX	18	2,900	1947-1948	1949-1980
241-TY	6	2,900	1951-1952	1953-1979
241-U	12 4	2,000 210	1943-1944	1946-1980

A.1.2 Tank Waste Management Experience

As a result of using several different plutonium recovery and radioisotope separations processes at the Hanford Site, the chemical and radionuclide compositions of existing individual tank contents vary significantly. Volumes and compositions of the wastes generated were strongly dependent upon the process used. Methods for treating the waste in the tanks also had major impacts on the compositions of tank contents. These treatment methods included the following:

- In-tank scavenging of strontium and cesium by the precipitation of strontium phosphate and cesium ferrocyanide to reduce the concentration of ^{90}Sr and ^{137}Cs in supernatant liquids and disposal of the supernatant liquids as LLW

- Removal of ^{90}Sr and ^{137}Cs at B Plant to reduce in-tank heat generation and allow concentration of the remaining waste
- Concentration of tank contents by evaporation of water to crystallize the waste as a saltcake.

Tank contents were partially mixed as a result of pumping solutions and slurries among tanks and tank farms during the treatments mentioned above.

A.1.3 Tank Waste Retrieval History

Two major tank waste retrieval campaigns have been undertaken at the Hanford Site. From 1952 to 1957, retrieval operations were conducted in seven tank farms involving 43 SSTs as part of a process to recover uranium from tank waste. The materials retrieved were sludges that ranged in density from 1.8 to 3 g/Ml. A total of 9,730 m^3 (3.57 Mgal) of sludges and 70,600 m^3 (18.64 Mgal) of supernatant were retrieved during this campaign. A second campaign, from 1962 to 1978, involved the retrieval of strontium-bearing wastes from 10 SSTs in 241-A and 241-AX Tank Farms. The sludge properties from these tanks ranged from 1.3 to 1.99 g/Ml and a total of 4,675 m^3 (1.235 Mgal) was retrieved during the campaign.

These campaigns used sluicing and slurry pumping for tank waste retrieval. The equipment and technologies used were based on mining industry practices and adapted for use in radioactive service. Equipment failures occurred and process limitations were experienced, but overall, the campaigns generally were successful and achieved a high overall removal efficiency. In most tanks, sluicing was terminated when it was no longer cost-effective to continue operations to gain a few additional inches of storage space. Freeing up tank space for storage of newly created waste was an important goal of these historic campaigns. Leaks that occurred during sluicing in two underground storage tanks led to the termination of waste retrieval activities in those tanks.

The materials retrieved during sluicing were a variety of sludges. Saltcake, which constitutes more than two-thirds of the current SST inventory, was not a waste form involved in these early retrieval efforts. The history of both campaigns is documented in *Hanford Tank Sluicing History* (Rodenhizer 1987).

A.1.4 Tank Leaks and Unplanned Releases

Tank wastes have been released to the ground as a result of leaks from SSTs and associated transfer lines, and other miscellaneous spills. Sixty-seven SSTs are assumed to have leaked a total volume of approximately 2,271 to 3,407 m^3 (600,000 to 900,000 gal) (Hanlon 1993).

In addition to the 67 assumed leaking tanks, at least 378 m^3 (100,000 gal) of liquid wastes are estimated to have been released to the ground as a result of unplanned releases and spills. The information available for these releases and spills indicates generally low levels of radioactivity. One significant release of long-lived fission products to the ground occurred in 241-C Tank Farm between 1969 and 1971. A release in 1971 resulted in the addition of an estimated 9.25×10^{14} Bq (25,000 Ci) of ^{137}Cs to the ground.

A.1.5 Interim Stabilization and Isolation Activities

Interim stabilization involves the removal of supernatant and interstitial liquid from the SSTs to the extent technically and economically feasible. Isolation of an SST involves physical modifications to tank structures to preclude the inadvertent addition of liquid to the tank.

The purpose of interim stabilization is to minimize the spread of contamination if the tanks begin to leak. The SSTs containing more than 50,000 gal of drainable liquid (or more than 5,000 gal of free-standing supernatant) are pumped. SSTs containing less than this amount are not pumped because attempting to remove the residual liquid would result in no significant decrease in risk to public health and the environment and radiation doses to operating personnel would increase. Approximately 100 SSTs have been interim-stabilized to date. Except for Tank 241-C-106, all interim-stabilization activities will be completed by the year 2000.

A.1.6 Hanford Site Defense Waste Environmental Impact Statement

The DOE addressed disposition of DST and SST waste, and cesium and strontium capsules at the Hanford Site in the *Final EIS, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987). This document is frequently referred to as the Hanford Defense Waste (HDW) Environmental Impact Statement (EIS) or HDW-EIS. In April 1988, in the Record of Decision (ROD) for the HDW-EIS, DOE decided to proceed with preparing the readily retrievable DST waste for final disposal. Wastes were to be processed in a pretreatment facility (planned to be the Hanford Site B Plant and AR Vault) to separate DST waste into two portions. The larger portion would be low activity waste, whereas a much smaller portion would be highly radioactive. The low-activity waste was to be mixed with a cement-like material to form grout. The grout was to be poured into large, lined, concrete, near-surface underground vaults. The high-activity fraction was to be made into a borosilicate glass and poured into stainless-steel canisters at a Hanford Site Waste Vitrification Plant. The canisters were to be stored at the Hanford Site until a geologic repository was ready to receive this waste.

In the HDW-EIS ROD, DOE decided to conduct additional development and evaluation before making decisions on final disposal of SST wastes. This development and evaluation effort was to focus on methods to retrieve and process SST wastes for disposal. The SST waste was to continue to be stored and monitored in the interim. Before a decision on the final disposition on these wastes could be made, the alternatives for the final disposal were to be analyzed in a supplement to the HDW-EIS.

A.1.7 New Technical Strategy

There have been several significant developments subsequent to the HDW-EIS. These include the identification of significant waste tank safety issues; the signing of the *Hanford Federal Agreement and Consent Order* (Tri-Party Agreement) by the DOE, U.S. Environmental Protection Agency (EPA), and Ecology (Ecology et al. 1994); and the programmatic decision to include SST waste in the tank waste remediation/retrieval program. As a result, resolving waste tank safety issues and planning for SST waste retrieval have become major elements of the Hanford Site tank program. These changes resulted in the need to integrate management of related tank waste programs. As a result, DOE established the Tank Waste Remediation System (TWRS) program to integrate Hanford Site tank efforts.

A.1.7.1 Safety Issues. The most significant TWRS program safety issues to be resolved involve flammable gases, ferrocyanides, organic and nitrate compounds in the tanks, and high-heat waste. The most severe hazard associated with flammable gases, ferrocyanide, or organic and nitrate chemicals in the waste tanks is the potential for explosion. Nuclear criticality is another hazard that must be considered in planning retrieval of tank wastes, although its probability of occurrence generally is regarded as low.

Forty-five SSTs have been identified as watch-list tanks. Conditions in these tanks could lead to onsite or offsite radiation exposure through an uncontrolled release of fission products. There are four categories of safety issues:

- Tanks containing > 1,000 g-mole of ferrocyanide (20 SSTs)
- Tanks with potential for hydrogen or flammable gas accumulations above the flammability limit (17 SSTs)
- Tanks containing concentrations of organic salts > 3 wt% total organic carbon (9 SSTs)
- Tanks with high heat loads (> 40,000 Btu/hr) (10 SSTs).

Tanks with safety issues are listed in *Tank Farm Surveillance and Waste Status Summary Report for September 1993* (Hanlon 1993). Some SSTs have more than one safety issue. Methods to mitigate or resolve the safety issues are being developed.

A.1.7.2 SST Waste Retrieval. The SST waste retrieval sequence is defined in *DST/SST Retrieval Sequence* (Williams 1993). First priority is placed on retrieving waste from tanks on the safety Watch List. Retrieval will then proceed farm-by-farm, based on available funding and completion of necessary infrastructure upgrades, to provide feed for waste treatment operations.

The DOE must retrieve waste from the SSTs to the extent practicable to meet the requirements of the Resource Conservation and Recovery Act (RCRA) for hazardous waste, and the Nuclear Waste Policy Act for nuclear waste. Radioactive waste has been retrieved successfully from Hanford Site underground tanks in the past using sluicing technology. However, the highly variable waste characteristics, degradation of the tank structures and systems, and changes in regulations make the present task of retrieval a more difficult challenge.

A.1.7.3 Technical Strategy Elements. The proposed new technical strategy for the TWRS Program is to minimize the environmental, safety, and health risks for storage, treatment, and immobilization of the Hanford Site tank wastes. The strategy includes the following elements.

- Retrieve wastes from the SSTs and DSTs.
- Accelerate remediation of safety concerns.
    - Mitigate and/or resolve, as soon as possible, safety issues such as periodic venting of flammable gases and ferrocyanides.
    - Pump liquids from SSTs to reduce the environmental impacts from leaks.
    - Develop barrier technology to control contamination spread.
- Upgrade tank farms.
    - Improve instrumentation such as leak detection systems and automatic data collection systems.
    - Upgrade tank facilities, procure new transfer systems, ventilation and other necessary equipment.
    - Build needed tanks to support tank waste remediation and environmental cleanup.
- Proceed to treat liquid and saltcake wastes with existing technologies while developing and demonstrating improved pretreatment technologies by 1997. Initiate full-scale cleanup of Hanford Site tank waste upon successful demonstrations. Vitrify and dispose of the treated LLW fraction onsite and store the high-level waste (HLW) fraction as consolidated sludge to facilitate processing and immobilization by vitrification.

- Delay processing of sludge to allow parallel technology development for maximum pretreatment and high-capacity vitrification (neither technology is currently available) for selection of the preferred technology. Upon technology selection, immobilize the HLW for disposal offsite in the geologic repository.

A.2 TANK FARM ARRANGEMENT AND WASTE INVENTORIES

This section describes the physical characteristics of the Hanford Site tank farms and provides a summary of the SST waste chemical and radiological inventories.

A.2.1 Hanford Site Tank System

The tank system consists of 177 tanks grouped in 18 tank farms, as shown in Figure A-1. The SST portion of the system consists of 149 tanks grouped in 12 tank farms. The SSTs have the following four capacities.

- Sixteen tanks have a 210 m^3 (55,000 gal) capacity.
- Sixty tanks have a 2,000 m^3 (533,000 gal) capacity.
- Forty-eight tanks have a 2,900 m^3 (758,000 gal) capacity.
- Twenty-five tanks have a 3,800 m^3 (1 Mgal) capacity.

Schematics showing elevation views of these four different types of tanks are provided as Figure A-2. Figure A-3 shows an elevation view of a typical SST with instrumentation and equipment access ports. Wall-to-wall spacing between individual SSTs ranges from 25 to 30 ft.

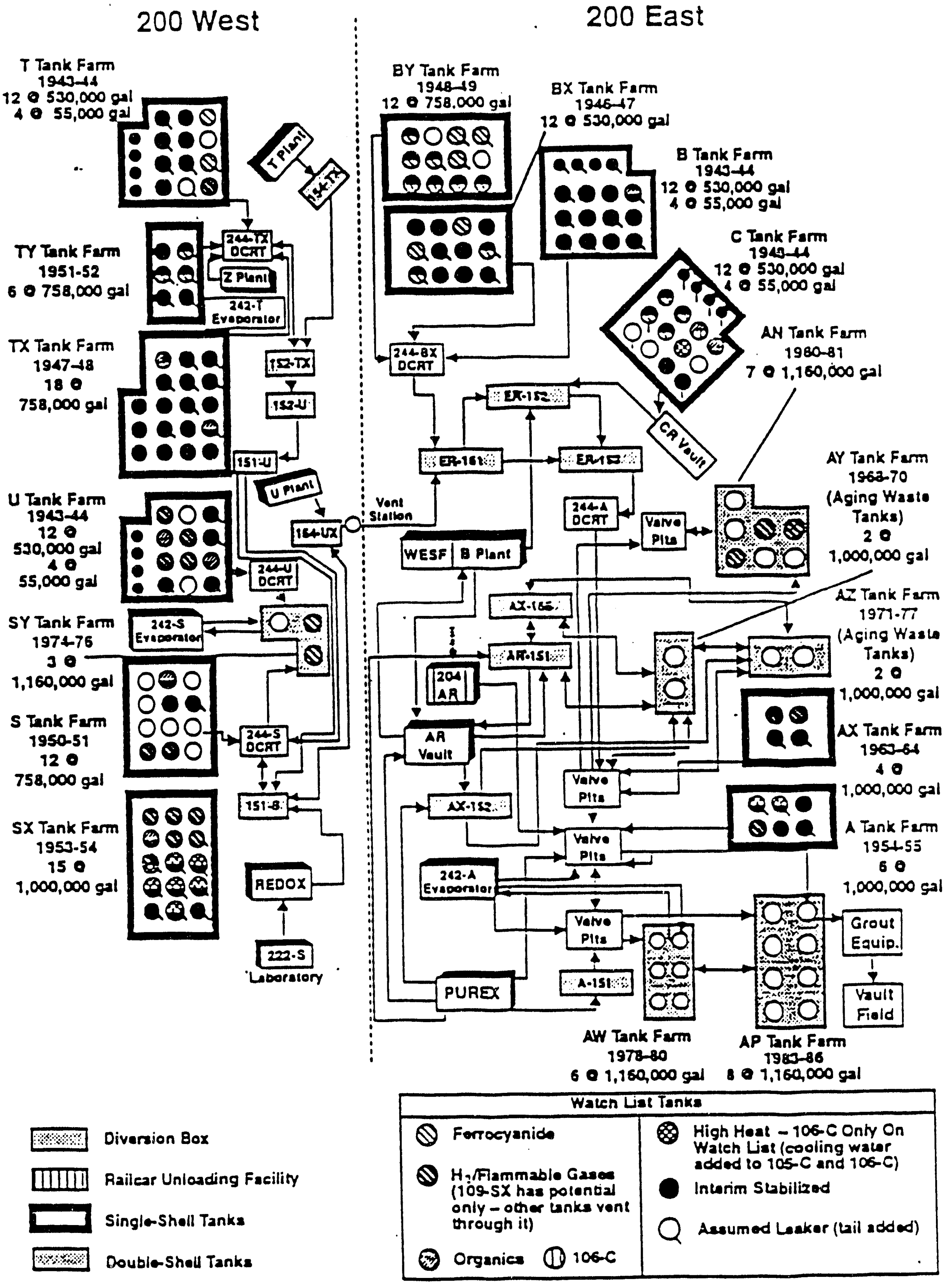
There are 133 SSTs classified as 100 series tanks and 16 classified as 200 series tanks. All 100 series tanks are 22.9 m (75 ft) in diameter with domed tops. Tank volumes are either 2,000 m^3 (533,000 gal), 2,900 m^3 (758,000 gal), or 3,800 m^3 (1 Mgal). The 2,000 m^3 (533,000 gal) and 2,900 m^3 (758,000 gal) tanks originally were arranged in "cascades" of three, four, or six tanks. These tanks were connected by piping in a manner such that when the first tank in a cascade was filled it overflowed to the second tank, which overflowed to the third tank, and so on. Tank farms with this arrangement include the following:

- 241-B
- 241-BX
- 241-BY
- 241-C
- 241-S
- 241-T
- 241-TX
- 241-TY
- 241-U

Access to SSTs is by risers penetrating the dome of the tank. Risers are vertical pipes or ducts ranging from 10.2 cm (4 in.) to 106 cm (52 in.) in diameter. Both sampling and retrieval efforts have been conducted using risers for access. The number of risers available for sampling varies from tank to tank, depending on the number of risers existing on the tank, location in the tank, and the equipment that may be in or around the riser. Technology is being developed to add risers to some tanks if an evaluation finds that the potential for biased results exists because samples are taken using only existing risers. The waste retrieval program has proposed systems using the existing risers in the tanks and new openings of up to 14.6 m (48 ft) diameter.

The 200 series tanks are similar in construction to the 100 series tanks. They feature a 6.1 m (20 ft) diameter, a capacity of 210 m^3 (55,000 gal), and a flat top. These tanks are covered with approximately 3.7 m (12 ft) of soil. These 16 tanks are located in the 241-B, 241-C, 241-T, and 241-U Tank Farms in groups of four.

Figure A-1. Hanford Site Tank Farm System Summary.



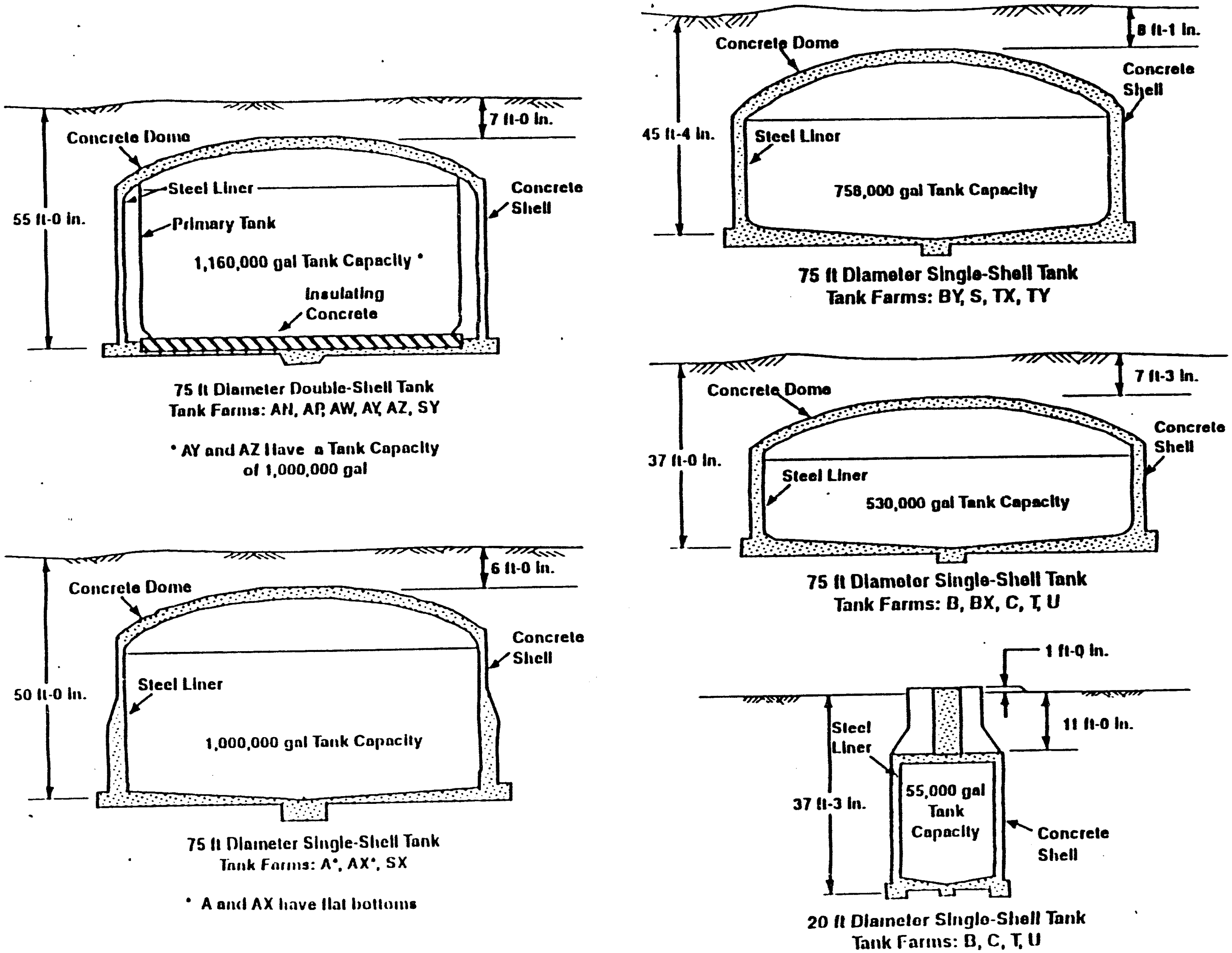
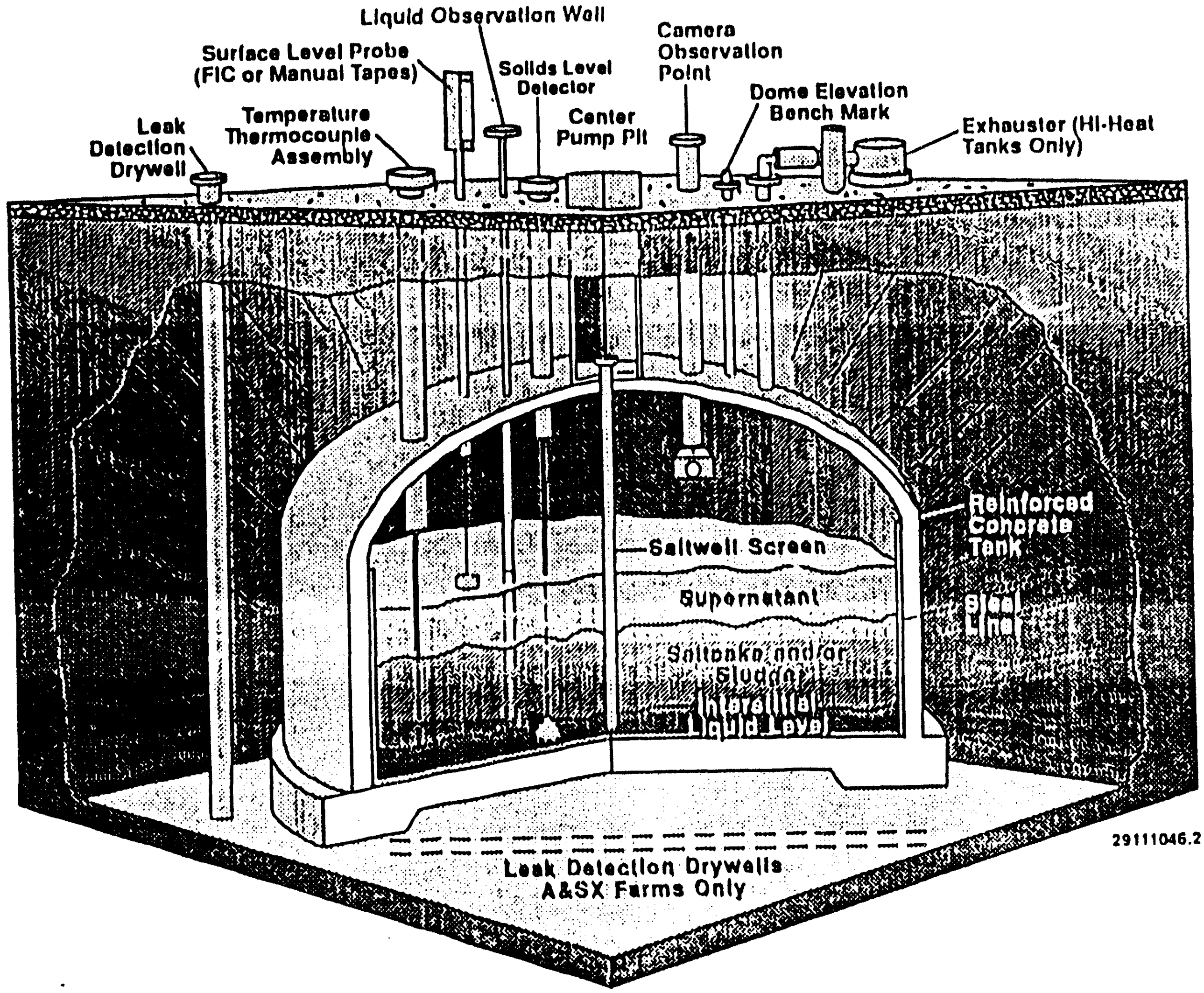


Figure A-2. Dimensions of Hanford Site Single-shell Tanks and Double-Shell Tanks.

Figure A-3. Instrumentation and Equipment Access Ports to Typical Single-Shell Tanks.



A.2.1.1 In-Tank Equipment and Materials. Many SSTs contain equipment and materials that were discarded when storage and transfer operations, full-scale experiments, and development activities were occurring. This hardware includes large installed equipment, such as air-lift circulators, thermocouple trees, coils, and sluicers. Also included in some tanks are experimental fuel elements, cobalt slugs, diatomaceous earth, portland cement, and other miscellaneous items such as sampling bottles. The tanks also contain instrumentation to monitor liquid level, specific gravity, and temperature. The tanks are on either active or passive ventilation. Air samplers, airflow measuring devices, and radiation monitors are installed on the ventilation systems to monitor releases to the environment. Ventilation equipment and associated instrument controls filter the supply and exhaust, and maintain the tank under a negative pressure.

A.2.1.2 Ancillary Equipment. Ancillary equipment associated with the tank farms was used for transferring liquid between the tanks. The equipment consists of diversion boxes, valve pits, jumper pits, 241-CR vault, double-container receiver tanks, cribs, and catch tanks. Most of the access lines and ports to SSTs have been sealed to prevent inadvertent addition of water and waste. Dry wells located within the tank farms are used to monitor the soil for radioactivity and serve as leak detection systems. The dry wells extend below the bottoms of the tanks to a depth of 12.1 to 45.7 m (40 to 150 ft). Some tank farms also have horizontal dry wells that run approximately 3.0 m (10 ft) beneath the tanks. Most of the ancillary equipment is associated with RCRA past-practice units and will require corrective actions in accordance with the requirements of WAC 173-303-610. These corrective actions must be coordinated with SST waste retrieval and tank closure activities.

A.2.2 Chemical Composition of Tank Waste

The estimated chemical compositions of SST wastes are based on process records of fuel elements processed, chemicals used, and a limited number of waste sample analyses. Chemical compositions of the wastes vary widely from tank to tank. Estimates of average chemical inventories by ionic species are listed for SSTs in Table A-2.

Table A-2. Average Chemical Inventories Associated with Existing Single-Shell Tank Wastes. (Boomer 1994)

Chemical Component[a]	Total Sludge (Mg)	Total Salt Cake (Mg)	Interstitial Liquid (Mg)
Na^{+}	15,000	34,000	2,300
Al^{+3} [b]	1,100	630	490
Ce^{+3}	230		
$Cr^{+3,+6}$	96		
Cd^{+2}	4		
Fe^{+3}	630		
Sr^{+2}	36		
Bi^{+3}	260		
Ca^{+2}	130		
Hg^{+}	1		
Cl^{-}	40		
F^{-}	800		
NO_3^{-}	15,000	80,000	5
NO_2^{-}	2,000	1,500	1,800
PO_4^{-3}	7,400	1,200	1,300
OH^{-}	4,100	850	160
SO_4^{-2}	500	1,100	310
CO_3^{-2}	1,200	410	
MnO_2	190		40
$Ni_2Fe(CN)_6$	500		
$P_2O_5 \cdot 24WO_2 \cdot 44H_2O$	20		
$ZrO_2 \cdot 2H_2O$	430		
Organic carbon			200
Cancrinite[c]	2,700		
H_2O	26,000	14,000	4,800
Totals[d]	78,000	134,000	11,000

NOTES:
Most minor components (< 100 Mg total) are not listed.
To convert Mg to lb, multiply by 2.20 E+03. (Mg = million grams)
[a]Values taken from RHO-RE-ST-30P, Table 2-5 (RHO 1985).
[b]Aluminum is present as Al^{+3} and as AlO_2^{-} but is listed as Al^{+3}.
[c]Known silica additions are assumed to have reacted with aluminates and hydroxides to form cancrinite (assumed to be $2NaAlSiO_4 \cdot 0.52NaNO_3 \cdot 0.68H_2O$).
[d]Totals are rounded. Totals do not match RHO-RE-ST-30P (RHO 1985) because of AlO_2^{-} being listed as Al^{+3}.

Mechanical handling properties of the SST waste range from those of a dry crystalline material that is nearly as hard as concrete, to those of mushy wet solids that have a no structural integrity. The waste characteristics that must be known to support design of waste retrieval equipment are particle size distribution, bulk density, radiation levels, penetration resistance, shear strength/shear rate, shear and compressive strength, and abrasiveness. Currently, the waste retrieval equipment is being tested on waste simulants because, to date, there are very little data on the physical characteristics of the waste.

A total of about 140,000 m^3 (37 Mgal) of waste is stored in SSTs. Of this waste, about 2,300 m^3 (600,000 gal) is supernatant, 89,000 m^3 (23 Mgal) is saltcake, and 48,000 m^3 (12 Mgal) is sludge as classified in the *Tank Farm Surveillance and Waste Status Report for September 1992* (Hanlon 1992). The saltcake consists of a solid form of the various salts created by evaporating liquid alkaline waste. The saltcake consists primarily (approximately 93 wt%) of sodium nitrate and sodium nitrite. The sludge consists of the solids (hydrous metal oxides) precipitated in the neutralization of acid waste before it could be transferred to the SSTs. Some of the salt associated with hot slurries from the evaporators precipitated with the sludge. As a result of the precipitating salt, roughly 50 percent of the reported sludge volume is saltcake. The liquid solution in SSTs exists as supernatant and interstitial liquids. An estimated 23,000 m^3 (6 Mgal) of drainable interstitial liquid is present in SST saltcake and sludge. Table A-3 shows the estimated amounts of saltcake, sludge, and liquids in each tank farm (Hanlon 1992). The amounts of saltcake, sludge, and liquids vary widely in individual tanks.

The SSTs primarily contain inorganic waste, although relatively small amounts of organic wastes, such as solvents, are present that were entrained with the aqueous waste during fuel reprocessing. Also, water-soluble complexing agents and carboxylic acids added in a fractionation process are in some SST wastes. A listing of all nonradioactive chemicals known to have been used at production plants and support facilities that transferred waste to SSTs has been documented in *Inventory of Chemicals Used at Hanford Production Plants and Support Operations (1944-1980)* (Klem 1990). Specific chemicals that may have been transferred to the SSTs (Klem 1990) and that appear on the "Dangerous Waste Sources List" (WAC 173-303-9904), include carbon tetrachloride (Ccl_4), methylene chloride, hexone, acetone, and ethyl ether. Chemical reactions (e.g., oxidation-reduction, neutralization, precipitation) and radiolysis have converted many of these chemicals into different compounds. Dangerous waste sources are discussed in WAC 173-303-082 and listed in WAC 173-303-9904.

On the "Dangerous Waste Sources List," only chemicals from the sources numbered F001, F002, F003, F005, and WP002 are likely to be found in the SSTs.

The wastes are considered to be dangerous waste sources if they were used as solvents before being discarded to the SSTs.

Table A-3. Summary of Physical Characteristics of Single-Shell Tank Waste.

Tank Farm	Number of Tanks	Salt Cake (m^3)	Sludge (m^3)	Super-natant (m^3)	DSS (m^3)	Total Vol. (m^3)	Vol. % Salt	Vol. % sludge	Vol. % super-natant	Vol. % DSS	Drainable Liquid in Solids (m^3)	Drainable Liquid % in Solids Volume	% Total Salt	% Total Sludge	% Total Super-natant	% Total DSS	% Total Drainable Liquids	% Total Vol.
200 West																		
241-S	12	18,036	4,432	174	0	22,642	80	20	1	0	5,295	24	20	8	0	0	21	10
241-SX	15	10,818	5,799	238	0	16,855	64	34	1	0	4,773	31	12	11	0	0	19	7
241-T	16	0	7,536	280	0	7,816	0	96	4	0	715	9	0	14	0	0	3	3
241-TX	18	25,204	912	19	0	26,135	96	3	0	0	946	4	27	2	0	0	4	11
241-TY	6	242	2,161	11	0	2,415	10	89	0	0	117	5	0	4	0	0	0	1
241-U	16	10,386	2,415	636	0	13,437	77	18	5	0	4,307	34	11	4	1	0	17	6
200 East																		
241-A	6	3,679	2,104	30	0	5,814	63	36	1	0	1,662	29	4	4	0	0	7	3
241-AX	4	3,346	72	11	0	3,429	98	2	0	0	1,400	41	4	0	0	0	6	1
241-B	16	1,306	6,423	57	0	7,786	17	82	1	0	621	8	1	12	0	0	3	3
241-BX	12	587	5,125	189	0	5,901	10	87	3	0	587	10	1	9	0	0	2	3
241-BY	12	15,235	2,721	0	0	17,956	85	15	0	0	2,952	16	17	5	0	0	12	8
241-C	16	0	7,483	648	0	8,123	0	92	8	0	541	7	0	14	1	0	2	4

A.2.3 Radionuclide Composition of Tank Waste

The radioactive components of SST wastes primarily consist of fission product radionuclides, such as ^{90}Sr and ^{137}Cs, and actinide elements, such as uranium, plutonium, and americium. The SST wastes contain an estimated 5.5 x 10^{18} Bq (1.5 x 10^{8} Ci).

Table A-4 lists estimates of SST radionuclide inventories. The radionuclide inventory varies widely from tank to tank. The total radionuclide inventory was based on RIBD (Gumprecht 1968) and Oak Ridge Isotope Generation and Depletion Code - revised (ORIGEN2) (Croft 1980a, 1980b) computer modeling of the spent fuel. The Hanford Site Track Radioactive Constituents (TRAC) code has been used to distribute the radionuclides among various tank farms and tanks based on (1) documented transfers from process facilities to the waste management system and (2) known or estimated chemical solubilities. These radionuclides values, with the exception of ^{90}Sr and ^{137}Cs, are consistent with those in RHO (1985). The ^{90}Sr and ^{137}Cs inventories are consistent with information in the 1991 integrated database (DOE 1991).

Table A-4. Existing Tank Waste Radionuclide Inventory. (Decayed to December 1990[a])

Radionuclide	Single-Shell Tank Radioactivity Total (Ci)	Half-Life (Years)
^{241}Am	4.6 E+04	430
^{243}Am	1.9 E+01	7,900
^{14}C	3.0 E+03	5,700
^{244}Cm	1.6 E+02	18
^{137}Cs, ^{137}Ba	3.5 E+07	30
^{129}I	2.4 E+01	17,000,000
^{63}Ni	3.0 E+05	92
^{237}Np	3.2 E+01	2,100,000
^{238}Pu	4.5 E+02	87
^{239}Pu	2.2 E+04	24,000
^{240}Pu	5.4 E+03	6,600
^{241}Pu	5.7 E+04	14
^{106}Ru	2.3 E+01	1
^{151}Sm	6.8 E+05	87
^{126}Sn	5.7 E+02	10,000
^{90}Sr, ^{90}Y	1.13 E+08	28
^{99}Tc	1.6 E+04	210,000
^{235}U	2.0 E+01	7.1 E+08
^{238}U	4.6 E+02	4.5 E+09
^{93}Zr	4.3 E+03	1,500,000

NOTES:
- To convert Ci to Bq, multiply by 3.7 E+10.
- [a]Values decayed to December 1990 (RHO 1985, DOE 1991); decay daughters are included for ^{137}Cs and ^{90}Sr.
- Value also includes ^{240}Pu.
- Other radionuclides are present in the waste but pose lower risks to worker safety, public health, and environmental safety than those listed.

A.3 TANK FARM GEOLOGY AND SEDIMENT PROPERTIES

All SSTs are located in the 200 East and 200 West Areas in the central part of the Hanford Site. The Hanford Site is situated in the Pasco Basin of south-central Washington State.

Interbedded sands and silts with only a few gravel layers predominate in the 200 East Area. Gravels of cobbles and boulders with layers of silt occur in the 200 West Area. Variations in the soil column beneath the tank farms exist even within individual tank farms. Clastic dikes are common in the vadose zone and can act as barriers or pathways for contaminant transport. Excavated material from construction was used for backfill around the tanks; typically this is medium- to coarse-grained sand and gravel. The moisture content of the sediment generally ranges from 2 to 4 wt% based on samples collected during the installation of groundwater monitoring wells. Estimates of the hydraulic conductivity of the vadose zone beneath the tank farms vary from 10^{-2} to 10 cm/sec. Porosity is estimated at 10 to 30 percent.

The stratigraphy of the Pasco Basin includes, in ascending order, the Columbia River Basalt Group, the Ellensburg Formation, Suprabasalt sediments, Ringold Formation, Plio-Pleistocene unit pre-Missoula gravels, early Palouse soil, Hanford formation, and a thin veneer of Holocene surficial deposits. Subsurface barriers will be installed in the Hanford formation.

The Hanford formation consists of pebble-to-boulder gravel, fine-to-coarse-grained sand, and silt. These deposits are divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) slackwater or normally graded rhythmite. The Hanford formation is thickest in the vicinity of 200 West and 200 East Areas where it is up to 65 m thick.

A.3.1 Gravel-Dominated Facies

This facies is dominated by coarse-grained-to-granular basaltic sands and granule-to-boulder gravels. These deposits display massive bedding, plane-to-low-angle bedding, and large-scale cross-bedding in outcrop while the gravels generally are matrix-poor and display an open-framework texture. Lenticular sand and silt beds are intercalated throughout the facies. Gravel clasts in the facies generally are dominated by basalt (50 to 80 percent). Other clast types include Ringold and Plio-Pleistocene rip-ups, granite, quartzite, and gneiss. The percentage of gneissic and granitic clasts in Hanford Site gravels versus Ringold gravels generally is higher (up to 20 percent versus less than 5 percent). Locally, Ringold and Plio-Pleistocene rip-up clasts dominate the facies, comprising up to 75 percent of the deposit. The gravel facies dominates the Hanford formation in the northern part of 200 East and 200 West Areas. The gravel-dominated facies was deposited by high-energy flood waters in or immediately adjacent to the main cataclysmic flood channelways. The thickness of the gravel facies ranges from 0 to 45 m (148 ft) in the 200 West Area and from 0 to 60 m (182 ft) in the 200 East Area.

A.3.2 Sand-Dominated Facies

This facies consists of fine-grained-to-granular sand displaying plane lamination and bedding and less commonly plane and trough cross-bedding in outcrop. These sands may contain small pebbles in addition to pebble-gravel interbeds and silty interbeds less than 1 m thick. The silt content of these sands is variable, but where it is low, a well-sorted and open-framework texture is common. These sands typically are basaltic, commonly being referred to as black, gray, or salt-and-pepper sands. This facies is most common in the central Cold Creek Syncline, in the central-to-southern parts of the 200 East and 200 West Areas. The laminated sand facies was deposited adjacent to main flood channelways during the waning stages of flooding and as water spilled out of channelways, losing competence. The facies is transitional between the gravel-dominated facies and rhythmite facies. The sand facies range in thickness from 0 to 92 m in the 200 East Area and is absent in the 200 West Area.

A.3.3 Slackwater Facies

This facies consists of thinly bedded, plane-laminated and ripple cross-laminated silt and fine- to coarse-grained sand that commonly display normally graded rhythmites a few centimeters to several tens of centimeters thick. This facies is found throughout the central, southern, and western Cold Creek syncline within and south of the 200 East and 200 West Areas. These sediments were deposited under slackwater conditions and in backflooded areas. The depth to slackwater facies ranges from 0 to 32 m (105 ft) in the 200 West Area and from 0 to 44 m (135 ft) in the 200 East Area.

Sediment characteristics vary widely in the Hanford formation as indicated above. Particle size distributions for two sediment samples from the 200 East and 200 West Areas are provided in Tables A-5 and A-6, respectively. The large difference in the particle size distribution are indicative of the wide variability in characteristics of sediments that may exist around a single tank or tank farm.

Table A-5. Sieve Analyses for Hanford Formation Sediments In 200 East Area Near B/BX Tank Farms. (Report on Well 0299-E33-028)

	Weight Percent						
Depth (ft)	Very Fine Pebble	Very Coarse	Coarse	Medium	Fine	Very Fine	Pan
10	27.3	12.8	19.2	13.2	9.2	7.5	10.7
20	69.6	6.7	5.1	4.9	3.6	3.1	7.0
30	27.8	27.6	19.6	10.8	5.7	3.6	5.0
40	6.7	25.7	38.5	11.5	8.9	3.2	5.6
50	5.3	21.0	36.0	19.7	8.6	4.4	5.1
60	15.5	20.2	30.4	18.5	7.8	4.0	3.6
70	3.4	16.7	25.5	33.0	15.0	5.1	1.4
80	4.4	30.0	45.3	14.1	3.6	1.4	1.2
90	5.1	31.4	51.4	6.2	3.6	2.2	0.2
100	2.3	11.7	48.3	27.4	5.5	2.3	2.5

PARTICLE DESIGNATION	PARTICLE DIAMETER (mm)
VERY FINE PEBBLE	2-4
VERY COARSE	1-2
COARSE	0.5-1
MEDIUM	0.25-0.5
FINE	0.125-0.25
VERY FINE	0.0625-0.125
PAN	<0.0625

Table A-6. Sieve Analyses for Hanford Formation Sediments In 200 West Area Near ZP Tank Farms. (Report on Well 0299-W15-018)

	Weight Percent						
Depth (ft)	Very Fine Pebble	Very Coarse	Coarse	Medium	Fine	Very Fine	Pan
10	11.5	11.9	13.4	22.2	28.6	7.5	4.9
20	0.1	0.0	0.5	8.3	48.5	28.6	14.0
30	4.0	39.6	34.0	7.3	1.8	3.0	10.4
40	0.1	0.2	4.2	22.9	25.9	31.1	15.8
50	0.0	0.0	0.0	0.7	N/A	67.8	31.5
60	0.1	0.7	5.6	31.3	46.8	9.1	6.4
70	0.0	0.0	1.5	18.3	46.5	22.0	11.7
80	0.0	1.9	22.7	35.9	16.7	12.9	9.9
90	0.0	0.0	1.2	14.5	43.8	23.1	17.4
100	0.2	0.4	3.0	13.5	47.8	26.0	9.1

PARTICLE DESIGNATION	PARTICLE DIAMETER (mm)
VERY FINE PEBBLE	2-4
VERY COARSE	1-2
COARSE	0.5-1
MEDIUM	0.25-0.5
FINE	0.125-0.25
VERY FINE	0.0625-0.125
PAN	<0.0625

A.4 REMEDIATION OPTIONS

Remediation of SSTs will include retrieval of tank waste followed by closure activities. Closure may include (1) removal of empty tanks, contaminated soil, and equipment and structures associated with RCRA past- practice units; (2) in-place treatment of empty tanks, soil and RCRA past- practice units; or (3) some combination of removal and in-place treatment.

Subsurface barriers may be used to contain liquids used in or released from SSTs during tank waste retrieval options. They may also be used to complement soil flushing, a form of in-place treatment that involves flushing the soil with water to remove mobile contaminants. After all waste retrieval/treatment activities are completed, the remediated sites will be capped with a surface barrier. Capping will be necessary when residual contamination remains.

A.4.1 Single-Shell Tank Waste Retrieval

At least three options may be capable of retrieving SST saltcake and sludge: (1) mechanical retrieval, (2) pneumatic retrieval, and (3) hydraulic retrieval. Methods for mitigating leaks from tanks may be required with hydraulic retrieval where the use of water is necessary to support retrieval operations.

A.4.1.1 Hydraulic Retrieval. A hydraulic retrieval system would use slurry transfer (pumping) to move the tank waste out of the tank. The equipment would include high-pressure, high-volume water jets, associated pumping and supply systems, slurry accumulation tanks, and sluicing water recirculation systems. The sluicing action of the water jets would dislodge and mobilize the waste, dissolve or disperse it in a slurry, and wash the waste to a slurry pump where it would be pumped to the surface and to the accumulation tanks. Here the material would be staged for recirculation of the decanted aqueous phase and storage or treatment of waste components.

Two concepts involving hydraulic retrieval are under consideration. They differ only in how the water jet would be maneuvered within the tank. Limited sluicing relies on an arm-based system (Figure A-4) to achieve precise maneuvering of a jet and/or nozzle, while the other concept, called large-volume sluicing or traditional sluicing uses individual, riser-mounted devices with more limited maneuverability (Figure A-5). Two types of sluicers are depicted. The first is a traditional sluicer with only vertical and horizontal nozzle rotation. The second type is an enhanced sluicer, which offers both rotation, translation, and other movements.

The riser-mounted system shown on the right side of the tank in Appendix B (Figure B-1) was the method successfully used in the past retrieval campaigns noted in Appendix B, Section B.1.2. As with pneumatic retrieval, hydraulic retrieval cannot remove large debris items.

A.4.1.2 Tank Leak Mitigation Methods. The potential for leaking contaminated liquid to the soil is a key issue with hydraulic retrieval or other retrieval methods that employ the use of water. A summary of methods for mitigating leaks from SST is provided in the following paragraphs..

Subsurface barriers would be used in combination with retrieval methods that employ the use of water in the SSTs. The barriers would be placed throughout an entire tank farm in advance of sluicing activities. The barrier would stop or slow migration sufficiently to allow for remediation of the contaminated soil as part of closure. Soil flushing, contaminant immobilization, in-situ vitrification, and soil removal are some of the soil remediation technologies under consideration to achieve closure.

Surface barriers would be used to prevent recharge of surface water and thus greatly slow the migration of contaminants. Surface barriers would be placed over an entire tank farm site as part of a final closure strategy.

Leakage from tanks may be minimized in most tanks by operating with a minimum free liquid depth [approximately 0.33 m (1 ft)]. Most SST leaks are believed to have occurred at elevations well above 0.33 m (1 ft) where liquid/vapor interfaces existed in the past (Boomer 1994). The prevention or plugging of tank leaks is potentially the most desirable method of leak mitigation. For example, an injected barrier material placed next to the tank surfaces may effectively encapsulate a tank to prevent leaks.

A.4.2 Post-Retrieval Tank Conditions

Following waste retrieval, each SST is assumed to contain a residue of no more than 1 percent [typically less than 9.5 m^3 (or approximately 2,500 gal)] of its initial waste volume (Boomer 1994). The residue will be distributed over internal tank surfaces, as well as in and on resident in-tank hardware. Tanks will also contain quantities of in-tank hardware, such as pumps, circulators, and structural and operations debris left behind by retrieval activities. Tank structures are currently stable but not relied upon to sustain additional loading.

A.4.3 Post-Retrieval Soil Conditions

Estimates of existing contaminated soil volumes and plume geometries (depth and areas) have been made based on available data and technical judgement (Boomer 1994). These estimates are provided in Table A-7. Contamination of the soil has resulted from tank and pipeline leaks, "steaming", condensation of waste liquids in the soil layer covering the tanks, and dripping of waste during replacement of failed tank equipment. Quantities of major contaminants estimated to be in the soil include the following:

- NO_3^- : 1,310,000 kg
- ^{137}Cs : 650,000 Ci
- ^{14}C : 54 Ci
- ^{99}Tc : 158 Ci
- ^{129}I : 0.46 Ci

Additional leakage from SSTs and contamination of the soil is expected depending on the types of retrieval systems and subsurface barriers (if any) that are employed.

A.4.4 Tank Farm Closure

The SST system comprises six operable units, which include the SSTs, transfer lines, diversion boxes, valve pits, jumper pits, double-contained receiver tanks, catch tanks, cribs, and contaminated soil from spills and leaks. Following waste retrieval, these operable units will be remediated in accordance with approved closure plans. All units located within the boundary of each tank farm will be closed in accordance with WAC 173-303-610. Ancillary equipment associated with the SSTs and previously classified as RCRA past-practice units is included with treatment, storage, and disposal units for the purpose of ensuring a consistent closure approach. Closure of the SSTs is to be completed by September 2024 per milestone M-45-06 of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology et al. 1994).

A.4.5 Surface Confinement

The retrieval, demolition, removal, and transport of contaminated SST wastes and other materials creates the potential for highly dangerous levels of occupational and environmental exposures if the contaminated materials are not adequately contained. These activities may be conducted within surface confinement structures to minimize impact to the environment and personnel and to mitigate the undesirable effects of inclement weather. Poor weather conditions often causes delays in conducting outside operational and maintenance activities at the Hanford Site.

Three confinement options are under consideration to provide confinement of airborne contamination. The first option, which involves confinement above a single tank, approaches confinement and removal of waste and materials on a tank-by-tank basis. The second option involves a multi-tank confinement system that addresses confinement of rows of tanks, and removal of waste and materials on a tank-by-tank basis. The third option employs a tank-farm-wide system that would confine an entire tank farm and include waste and material removal on a tank-by-tank basis. The RCRA past-practice units may be removed within the confinement system, along with tanks and soil. Removal of certain RCRA past-practice unit materials may be necessary as part of site preparation activities for tank waste retrieval.

Subsurface structural barriers may be considered for confinement where removal activities would undermine the stability of adjacent tanks and the confinement structure.

Figure A-4. Hydraulic Retrieval of Single-Shell Tank Waste. (Arm Based)

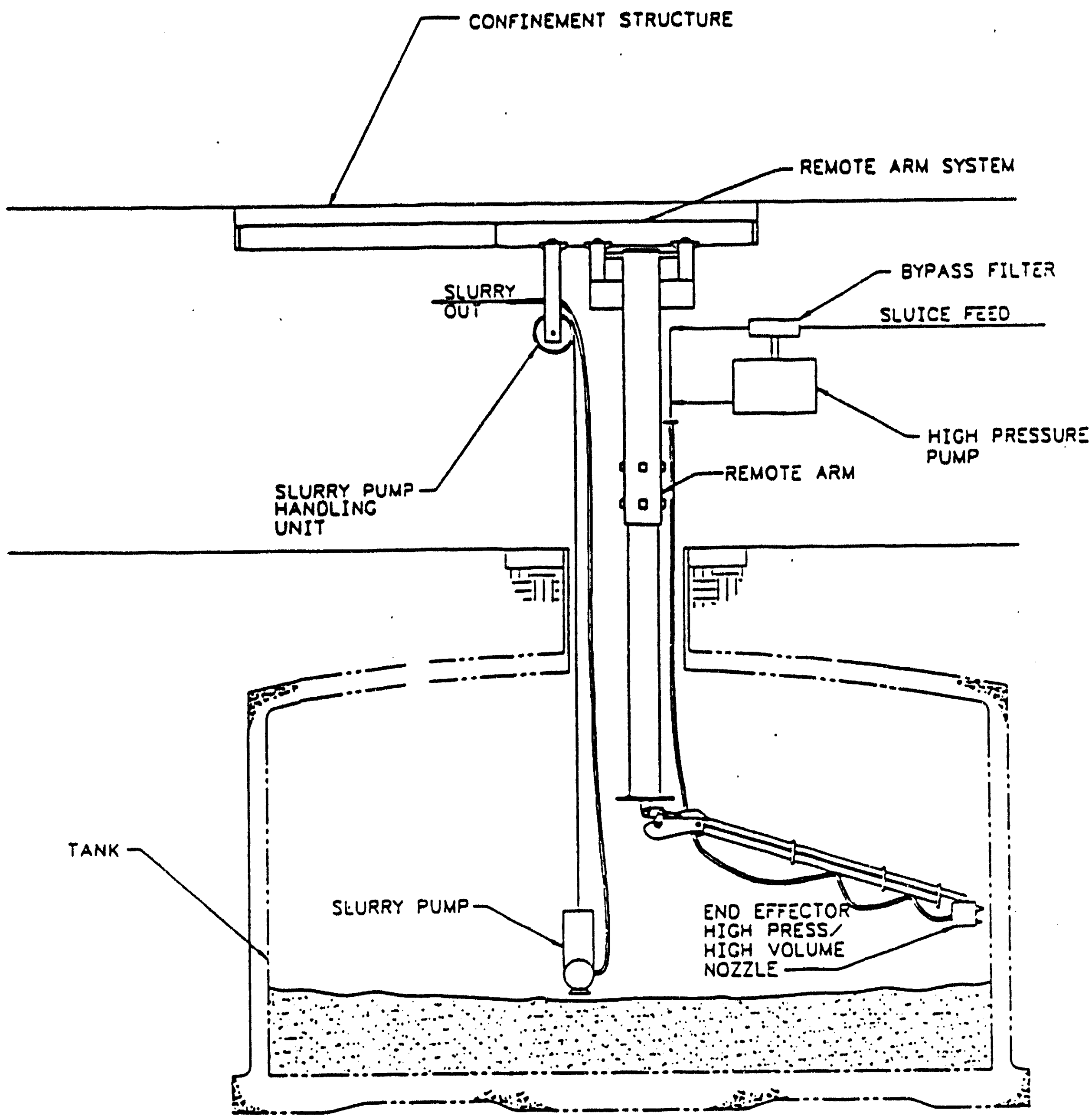


Figure A-5. Hydraulic Retrieval of single-Shell Tank Waste Using Convention Sluicing.

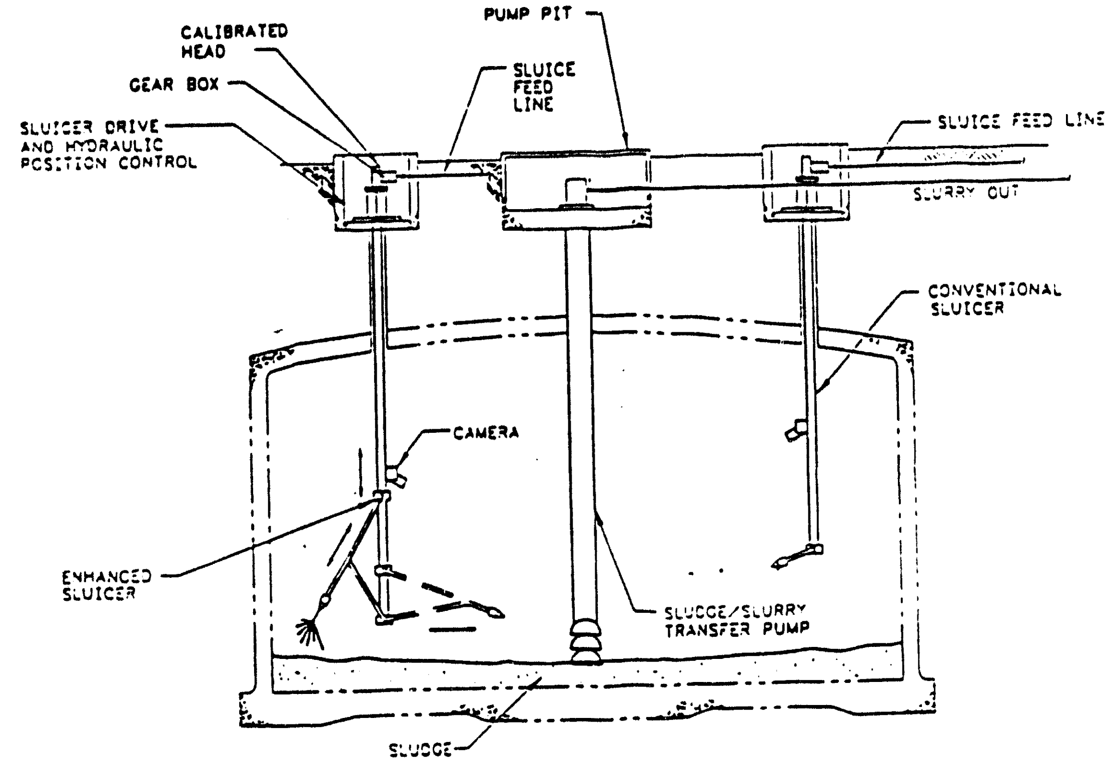


Table A-7. Estimates of Quantities of Contaminated Soil Resulting from SST Leaks (Boomer 1993). (Sheet 1 of 2)

Tank	Leak Volume (m^3)	Estimated contaminated soil volume (m^3)	Semiaxes (m)			Surface area 'footprint' (m^2)
			a	b	c	
A-103	20.8	1,187	8.0	10.3	3.4	259
A-104	9.5	539	6.2	7.9	2.6	153
A-105	37.9	2,158	9.8	12.6	4.2	386
AX-102	11.4	647	6.6	8.4	2.8	173
AX-104	30.3	1,726	9.1	11.7	3.9	333
B-101	30.3	1,726	9.1	11.7	3.9	333
B-103	30.3	1,726	9.1	11.7	3.9	333
B-105	30.3	1,726	9.1	11.7	3.9	333
B-107	30.3	1,726	9.1	11.7	3.9	333
B-110	37.9	2,158	9.8	12.6	4.2	386
B-111	30.3	1,726	9.1	11.7	3.9	333
B-112	7.6	432	5.7	7.4	2.5	132
B-201	4.5	-	-	-	-	-
B-203	1.1	-	-	-	-	-
B-204	1.5	-	-	-	-	-
BX-101	30.3	1,726	9.1	11.7	3.9	333
BX-102	265	15,104	18.7	24.1	8.0	1,413
BX-108	9.5	539	6.2	7.9	2.6	153
BX-110	30.3	1,726	9.1	11.7	3.9	333
BX-111	30.3	1,726	9.1	11.7	3.9	333
BY-103	18.9	1,079	7.8	10.0	3.3	243
BY-105	30.3	1,726	9.1	11.7	3.9	333
BY-106	30.3	1,426	9.1	11.7	3.9	333
BY-107	57.2	3,258	11.2	14.4	4.8	508
BY-108	18.9	1,079	7.8	10.0	3.5	243
C-101	75.7	4,315	12.3	15.8	5.3	613
C-110	7.6	432	5.7	7.4	2.5	132
C-111	20.8	1,187	8.0	10.3	3.4	259
C-201	2.1	-	-	-	-	-
C-202	1.7	-	-	-	-	-
C-203	1.5	-	-	-	-	-
C-204	1.3	-	-	-	-	-
S-104	90.8	5,178	13.1	16.8	5.6	692

Table A-7. Estimates of Quantities of Contaminated Soil Resulting from SST Leaks (Boomer 1993). (Sheet 2 of 2)

Tank	Leak Volume (m^3)	Estimated contaminated soil volume (m^3)	Semiaxes (m)			Surface area 'footprint' (m^2)
			a	b	c	
SX-104	22.7	1,295	8.3	10.6	3.5	275
SX-107	18.9	1,079	7.8	10.0	3.3	243
SX-108	9.1	518	6.1	7.8	2.6	149
SX-109	37.9	2,158	9.8	12.6	4.2	386
SX-110	20.8	1,187	8.0	10.3	3.4	259
SX-111	7.6	432	5.7	7.47	2.5	132
SX-112	113.6	6,473	14.1	18.1	6.0	803
SX-113	56.8	3,237	11.2	14.4	4.8	506
SX-114	30.3	1,726	9.1	11.7	3.9	333
SX-115	189.3	10,788	16.7	21.5	7.2	1,129
T-101	28.4	1,618	8.9	11.4	3.8	319
T-103	3.8	-	-	-	-	-
T-106	435.3	24,813	22.1	28.4	9.5	1,967
T-107	30.3	1,726	9.1	11.7	3.9	333
T-108	3.7	-	-	-	-	-
T-109	3.8	-	-	-	-	-
T-111	3.8	-	-	-	-	-
TX-105	30.3	1,726	9.1	11.7	3.9	333
TX-107	9.5	539	6.2	7.9	2.6	153
TX-110	30.3	1,726	9.1	11.7	3.9	333
TX-113	30.3	1,726	9.1	11.7	3.9	333
TX-114	30.3	1,726	9.1	11.7	3.9	333
TX-115	30.3	1,726	9.1	11.7	3.9	333
TX-116	30.3	1,726	9.1	11.7	3.9	333
TX-117	30.3	1,726	9.1	11.7	3.9	333
TY-101	3.8	-	-	-	-	-
TY-103	11.4	647	6.6	8.4	2.8	173
TY-104	5.3	-	-	-	-	-
TY-105	132.5	7,552	14.9	19.1	6.4	890
TY-106	73.7	4,315	12.3	15.8	5.3	613
U-101	113.6	6,473	14.1	18.1	6.0	803
U-104	208.2	11,867	17.3	22.2	7.4	1,203
U-110	30.7	1,748	9.1	11.7	3.9	336
U-112	32.2	1,834	9.3	11.9	4.0	347
TOTAL	2,887	162,387				23,091

Notes for Table A-7

1. Leak Volumes are from *Tank Farm Surveillance and Waste Summary Report for December 1992*, WHC-EP-0182-051 (Hanlon 1992).

2. Contaminated soil volumes are based on the ratio of 57 volumes of soil per volume of leaked waste, based on the leak from Tank 106-T.

3. The shapes of the plumes are estimated to be similar to the 106-T plume, which is an oblate ellipsoid with semiaxes in the ratio of 9:7:3. The 'c' semiaxis represents half of the height of the plume. (It does not include the depth from grade level to the site of the leak.)

4. Spills of 5.3 m^3 (1,400 gal) or less represent 1.3 percent of the contaminated soil volume, are uncertain estimates only, and have not been included in treatment.

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APPENDIX B

STATUS OF EMERGING TECHNOLOGIES

TABLE OF CONTENTS

List of Figures

ACRONYMS

BWID	Buried Waste Integrated Demonstration
CMST	Characterization, Monitoring, And Sensor Technologies
CMSTIP	Characterization Monitoring, And Sensor Technologies Integrated Plan
CRADA	Cooperative Research And Development Agreement
DOE	U.S. Department Of Energy
EM	U.S. Department Of Energy, Office Of Environmental Restoration And Waste Management
ID	Integrated Demonstration
IIA	Innovative Investment Area
IP	Integrated Program
METC	Morgantown Energy Technology Center
MWLID	Mixed Waste Landfill Integrated Demonstration
R&D	Research And Development
RDDT&E	Research, Development, Demonstration, Testing, And Evaluation
UST	Underground Storage Tank
VOC	Volatile Organic Compound

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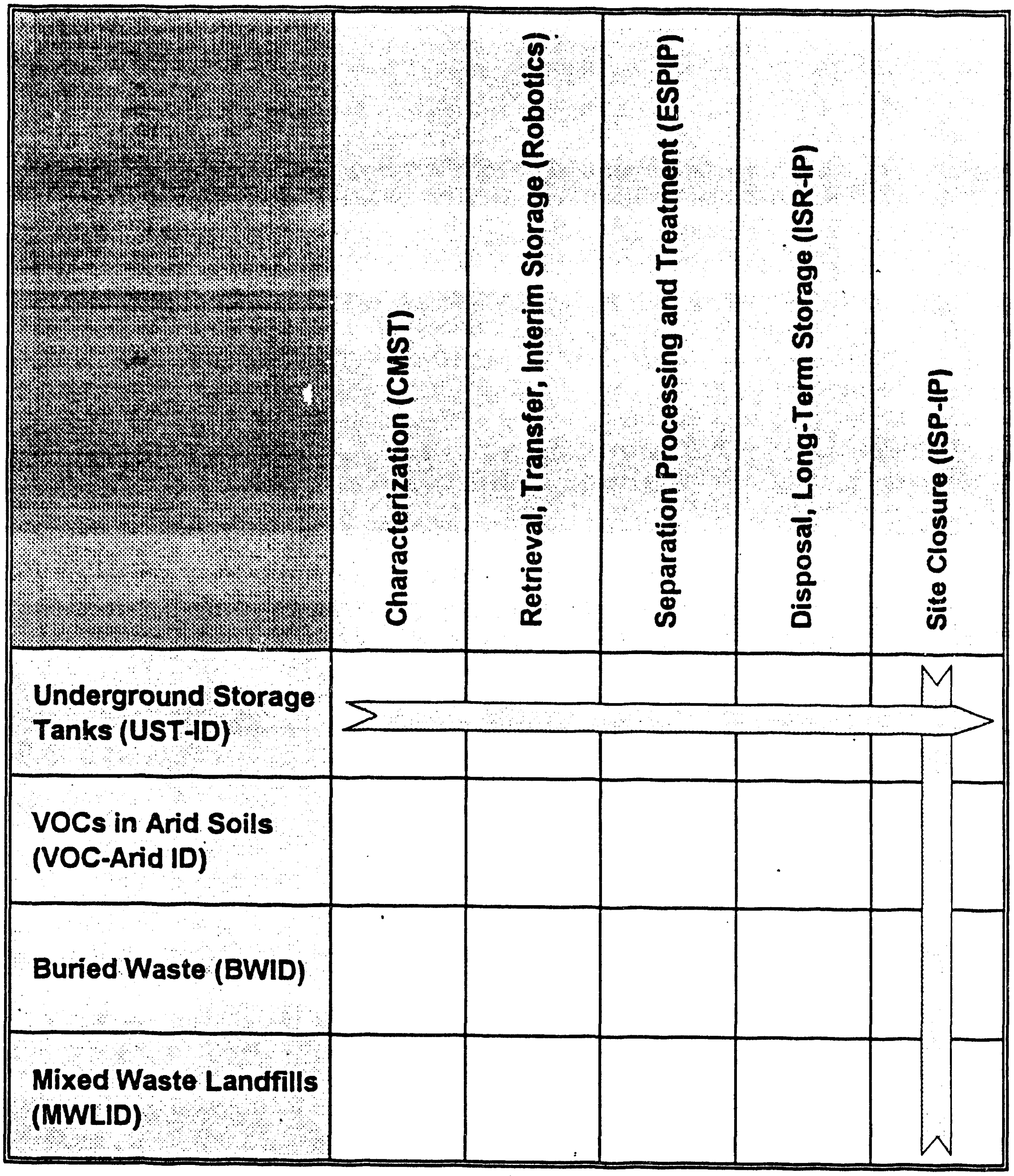
B.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of Environmental Restoration and Waste Management (EM) has undertaken the mission to restore the environment at the Hanford Site and other sites that were contaminated as a result of more than 40 years of nuclear weapons and materials production. Within EM, the Office of Technology Development (EM-50) is responsible for managing an aggressive national program of research, development, demonstration, testing, and evaluation (RDDT&E) for technologies that will help EM accomplish its mission. The EM-50 program is funding a number of technology development projects in the areas of monitoring and confinement of soil and groundwater contamination. Several integrated programs (IPs) and integrated demonstrations (IDs) and other EM-50 program elements have involvement. Participants in the Tank Waste Remediation System program are encouraged to contact the EM-50 programs for currently available data regarding the various concepts and systems in development. A summary of the EM-50 programs is presented in *U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Office of Technology Development - A National Program*, DOE/EM-0109P, October 1993. The paragraphs below summarize and provide points of contact for some of the related the EM-50 programs.

The IP and ID are management concepts created by the U.S. Department of Energy, Office of Technology Development to promote systematic development and effective application of advanced technologies to meet the EM's needs. An IP focuses research on one major technology area, and provides funds for specific technology development. An ID focuses on a cradle-to-grave solution to a particular problem, and often requires development and demonstration of several technology areas. Both Ids and Ips disseminate information on developing technology throughout the DOE. Figure B-1 shows some of the programs and their relationship to various waste problems. For example, the Underground Storage Tank - Integrated Demonstration (UST-ID) is developing systems addressing characterization, retrieval, processing, disposal, and site closure to support UST remediation efforts within the EM mission. The In-Situ Remediation - Integrated Program is focusing research on confinement and in-situ treatment technologies. The two programs have a natural interface in technologies related to UST closure.

Entire systems of technologies are evaluated in the Ids and Ips with respect to performance, safety, and cost effectiveness. Through collaborative partnerships with DOE laboratories, universities, federal agencies, and private industries, the developers of each technology are brought together with experts in the many facets of a demonstration. Chemists, geohydrologists, geophysicists, biologists, drilling engineers, environmental engineers, environmental modelers, materials scientists, and others involved in the project each approach the project from a unique perspective. Major savings in time and federal tax dollars can be realized by demonstrating multiple technologies at one test bed. Site characterization, modeling, and monitoring information can be shared, validated, and compared, thereby increasing the technical and interpretive value and improving evaluation of the technologies being demonstrated.

Figure B-1. Selected Integrated Programs/Integrated Demonstrations - Relationship to Tank Site Remediation



The foundation of the program is the technology base available from within the DOE and from external industrial and institutional programs that can be applied to the underground storage tank remediation efforts.

B.1 CHARACTERIZATION MONITORING AND SENSORS TECHNOLOGY

The Characterization, Monitoring, and Sensor Technologies Integrated Program (CMSTIP) was established in fiscal year 1991 to ensure that new and effective characterization, monitoring, and sensor technologies (CMST) are provided to DOE. The program conceives, supports and manages efforts in RDDT&E to characterize DOE sites and their waste and to monitor EM-related activities and processes. The CMSTIP focuses in the short-term on matching and adapting available characterization, monitoring, and sensor technologies to help solve EM problems at DOE sites. In the long-term, the program aims to stimulate, coordinate, and sponsor relevant research and development, and to promote and publicize available baseline and emerging CMST. The CMSTIP is designed to increase the effectiveness of known remediation approaches, and the viability of new options now limited by unacceptable characterization. A strategy is being developed to evaluate and establish priorities for rapid development, demonstration, and transfer of technologies, and to evaluate criticality of needs, cost savings, risk level, and regulatory concerns.

Contact: William Haas, Ames Laboratory, 515-294-4986

B.2 IN SITU REMEDIATION INTEGRATED PROGRAM

Using in-situ remediation technologies to clean up DOE sites may minimize adverse health effects on workers and the public by reducing contact exposure. They also can reduce the costs for cleanup by orders of magnitude by eliminating the need for waste excavation, transport, and disposal and enable the remediation of relatively inaccessible areas, such as the deep subsurface and areas beneath structures.

The ISR-IP has three primary DOE customers for its technologies: EM-50 Integrated Demonstrations, the Office of Environmental Restoration (EM-40), and the Office of Waste Management (EM-30). The ISR-IP is intended to link with fundamental and applied research and development (R&D) organizations to minimize duplication of effort and identify technology gaps. The objectives of the ISR-IP are to (1) develop and manage in-situ remediation technology R&D activities, (2) coordinate R&D to avoid duplication of effort and maximize communication, (3) develop in-situ remediation technologies to the point of field demonstration and transfer the technologies to the users, (4) support the assessment of innovative technologies, and (5) expand ongoing in-situ remediation technology R&D.

Contact: Mary Peterson, Pacific Northwest Laboratory, 509-372-4622

B.3 UNDERGROUND STORAGE TANK INTEGRATED DEMONSTRATION

The principal objective of the UST-ID is the demonstration and continued development of technologies suitable for the remediation of USTs. The most promising new technologies from industry, universities, national laboratories, and other government agencies are selected for demonstration, testing, and evaluation. The objective is the eventual transfer of new technologies as part of a system to full-scale remediation at DOE sites and alternately into the private sector. Technologies under development in the UST-ID program are targeted toward use in remediation actions at the following five DOE participant sites: Hanford, Fernald, Idaho, Oak Ridge, and Savannah River. Combined, these participant sites have more than 300 USTs containing more than 381,800 m^3 (100 Mgal) of high-level and low-level radioactive liquid waste.

Contact: Roger Gilchrist, Westinghouse Hanford Co., 509-376-5310

B.4 VOCS IN ARID SOILS INTEGRATED DEMONSTRATION

The Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID) focuses on technologies to clean up volatile organic compounds (VOCs) and associated contaminants in soil and groundwater at arid sites. The initial host site is the 200 West Area at DOE's Hanford Site in southeastern Washington State. The primary VOC contaminant is carbon tetrachloride, in association with heavy metals and radionuclides. An estimated 580 to 920 metric tons of carbon tetrachloride were disposed of between 1955 and 1973, resulting in extensive soil and groundwater contamination.

The VOC-Arid Integrated Demonstration is demonstrating technologies for all phases of remediation. These include drilling, site characterization and monitoring, retrieval of contaminants, above-ground treatment of contaminants, and in-ground treatment of contaminants.

Contact: Steve Stein, Battelle Pacific Northwest Laboratories, 206-528-3340

B.5 MIXED WASTE LANDFILLS INTEGRATED DEMONSTRATION

The mission of the Mixed Waste Landfill Integrated Demonstration (MWLID) is to demonstrate new technologies for cleanup of chemical and mixed waste landfills in contaminated sites that are representative of many sites occurring throughout the DOE complex and the nation. When implemented, these new technologies promise to characterize and remedy past waste disposal practices that have led to contaminated landfill sites across the country. Characterization and remediation technologies are aimed at making cleanup less expensive, safer, and more effective than current techniques. This will be done by emphasizing in-situ or in-place technologies, meaning that soils are not moved while the extent of the contamination is assessed (characterized), and the threat from the contaminant is safely mitigated. Most important, MWLID's success will be shared with other Federal, State and local governments, and private industry that face the important task of remediation at waste sites. The MWLID will demonstrate technology at two landfills. Sandia National Laboratories' Chemical Waste Landfill received hazardous (chemical) waste from the Laboratory from 1962 to 1985, and the Mixed-Waste Landfill received hazardous waste and radioactive wastes (mixed wastes) over a 29-year period (1959 to 1988) from various Sandia nuclear research programs. Both landfills now are closed. The sites were selected because of Albuquerque's arid climate and the thick layer of alluvial deposits that overlay groundwater approximately 146.3 m (480 ft) below the landfills. This thick layer of "dry" solids, gravel, and clays promised to be a natural barrier between the landfills and groundwater.

Contact: Jennifer E. Nelson, Sandia National Laboratories, 505-845-8348

B.6 BURIED WASTE INTEGRATED DEMONSTRATION

The mission of the buried waste integrated demonstration (BWID) is to advance innovative technologies for the retrieval and treatment of DOE Complex-wide buried waste. The BWID will accomplish this mission by employing a systems approach to support the development of a suite of advanced and innovative technologies for the effective and efficient remediation of buried waste. The BWID systems approach includes technologies for the entire remediation cycle, cradle to grave. Specifically, BWID supports technology development in the following categories: site and waste characterization, retrieval, preprocessing, ex-situ treatment, in-situ treatment, packaging, transportation, storage, and disposal. Examples of several technologies being developed by the BWID include those involved in aerial surveillance, robotics site characterization, cryogenic retrieval, remote sizing, and thermal treatment.

The BWID supports DOE environmental restoration programs and has been integrated into various remediation schedules, such as the Idaho National Engineering Laboratory Interagency Agreement, and the Tri-Party Agreement.

The BWID will accomplish its objectives by involving participants and technology sponsors from throughout their DOE complex, other Federal agencies, private industry, and the universities. This collaborative effort is being implemented to reduce duplication of effort, accelerate technology demonstrations, improve the remediation technology baseline, and leverage DOE funding.

Contact: Kevin Kostelnick, EG&G Idaho, Inc., 208-526-9642

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B.7 MORGANTOWN ENERGY TECHNOLOGY CENTER

The Morgantown Energy Technology Center (METC) has implemented a cooperative research and development agreement (CRADA) to establish industrial participation in subsurface barriers and other related technologies. The CRADAs are agreements between national laboratories and any non-Federal source to conduct cooperative R&D that is consistent with the laboratory's mission.

The METC activities are a part of the Innovation Investment Area (IIA), a component program in EM-50's Office of Technology Development. The mission of the IIA is to identify and provide development support to (1) technologies that show promise to address specific EM needs, but require proof-of-concept experimentation, and (2) already proven technologies in other fields that show promise of being adapted and applied to specific EM needs.

The Technology Development program is committed to ensuring that private industry and Federal agencies are major participants in developing and deploying technologies for Environmental Restoration and Waste Management. To this end, substantial funds are being set aside for interagency agreements and industrial participation. These funds will also be used to support R&D in areas not yet assigned to an ID or IP. Projects in this area may include unique, high risk, high payoff technologies.

Contact: Charles Zeh, Morgantown Energy Technology Center, 304-291-4265

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